# Industrial Challenges in Joining

## H2020 | MANUFUTURE | JOINING

2nd General Assembly Stakeholder Meeting

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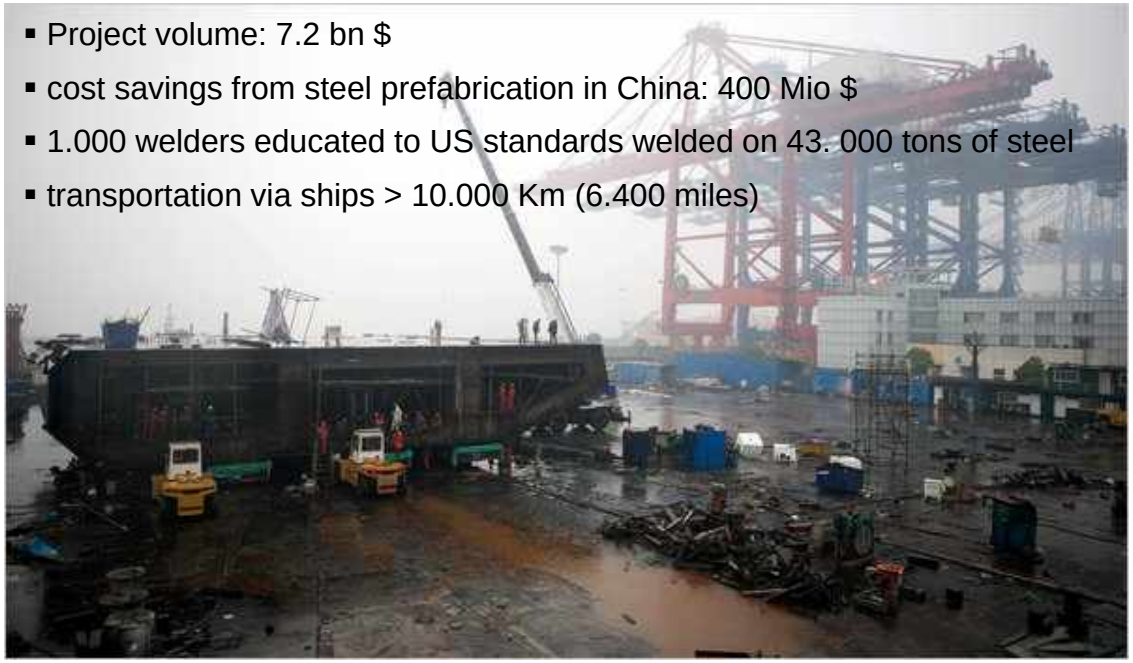



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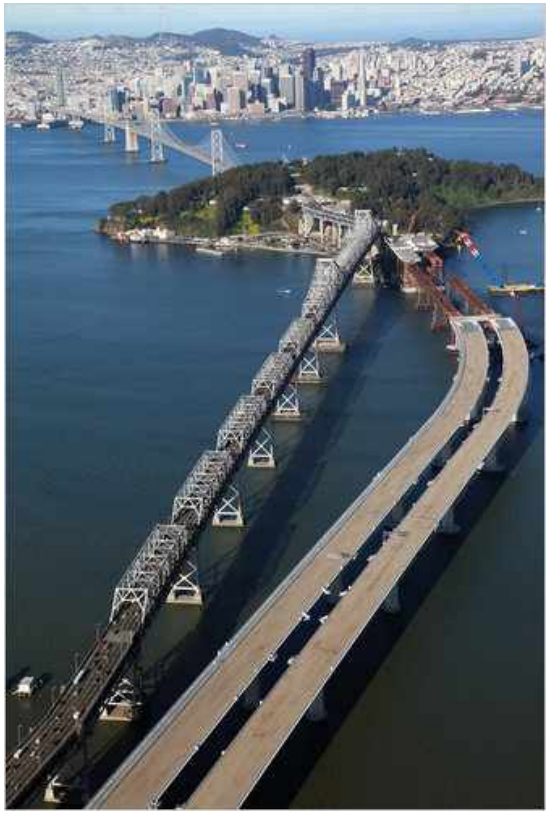
# Loosing competitiveness in JOINING = loosing value captured by local industry

**„Bridge Comes to San Francisco With a Made-in-China Label“**

June 25, 2011 / **The New York Times (source)**



- Project volume: 7.2 bn $
- cost savings from steel prefabrication in China: 400 Mio $
- 1.000 welders educated to US standards welded on 43. 000 tons of steel
- transportation via ships > 10.000 Km (6.400 miles)



What about the EU ?

➢ Fact: Over 3.8 million jobs have been lost in manufacturing in Europe since the beginning of the crisis 2008.

➢ Target: “European Industrial Renaissance”; to increase the contribution European industry makes to EU GDP from the current level of 15% to that of 20% by 2020 (source: EC Memo 19.03.2014, Advancing Manufacturing….)

➢ Industry statement: this will not happen without adequately competitive JOINING technology providers and users within the EU.

# “The Joining Industry” – main categories

Joining Technology Providers:

- produce and commercialise products & services for the joining in fabrication processes
- e.g. equipment: Welding machines, robots, Lasers, Plasma Cutters, protective equipment, etc.
- e.g. consumables: base materials, filler wires and powders, processing gases, etc.

**Shared challenges:**

**Competitiveness (in differing markets!)**

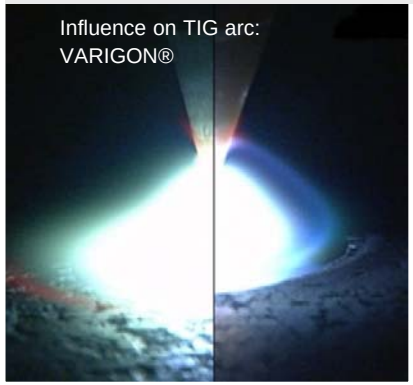
**Interdependent innovation**

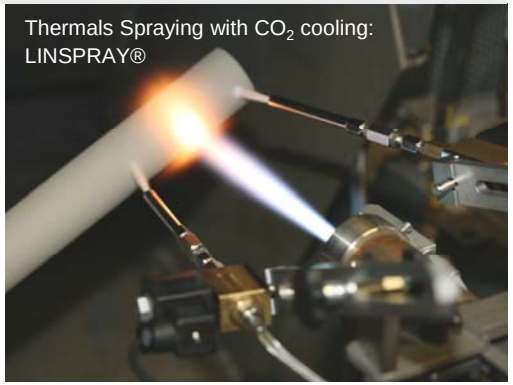
Joining Technology Users:

- produce and commercialise products & services applying the joining technologies in their value generation chain
- spans from single craftsmen enterprise to global industrial players
- apply different degree of regulation, quality control, automation and education
- act in different, specific competitive environment

## The Linde Group is both provider and user (selective examples)

Linde Gas Division: supplies worldwide processing gases for all joining technologies, services and application equipment


Influence on TIG arc: VARIGON®

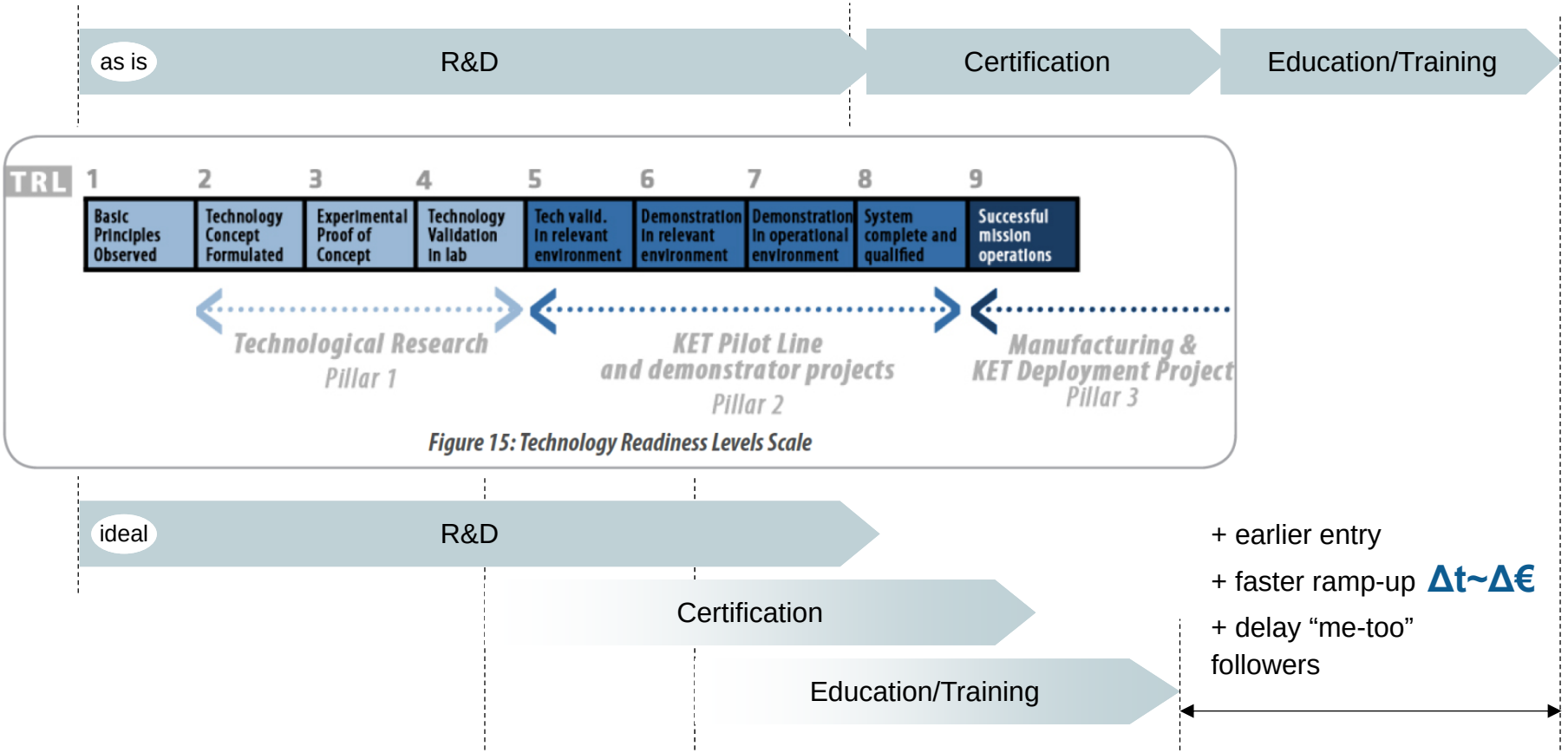

Thermals Spraying with $CO_2$ cooling: LINSPRAY®

Linde Engineering Division: uses joining technologies for process plant engineering and construction worldwide.


Aluminium coil wound heat exchangers fabrication


Stainless steel pressure vessel welding

# Challenge 1: time to market




- Joining technologies for demanding and high value products are often subject to certification and require special operator skills
- a strictly sequential model causes delay in market introduction, industry acceptance and sales ramp up
- earlier engagement of all relevant players in the project can shorten time to market; can this be imposed by H2020 funding ?

# Challenge 2: the pollutants - productivity vs. emissions dilemma

- Arc welding variants are the most used industrial technologies to join metals
  > 6.2m tons of filler were deposited globally in 2012
- Among these technologies, the group of Gas-shielded arc welding processes are dominant
  > 2 m tons of filler were deposited 2012 using welding gases; global trend ↗

Data sources: JWN 2013; Linde; BGI 593



TIG: using a non-melting electrode and “cold” filler

low — **Productivity** — high

1 Kg/h — 5 Kg/h

low — **Fumes emission** — high

<1 mg/sec — 2-25 mg/sec



MIG/MAG: using metallic electrode melted directly in the arc

- ➢ recent scientific cognition could prove overheated filler in MIG/MAG welding as main source for metal vapours and fumes (95%)
- ➢ Joining technology users are willing to invest in occupational health and safety but not wiling to compromise on productivity
- ➢ development of a highly productive (>MIG/MAG) arc joining technology with minimum emissions (<TIG) is overdue

# Challenge 2: the pollutants – different OHS standards

In recent years European regulation has significantly reduced occupational exposure limits affecting Joining. Examples: particulate fumes, hexavalent chromium, electromagnetic fields, optical radiation, NOx (pending)

Clarification: the joining industry takes responsibly care for it's employees, respects regulation and innovates to cope with new limits.

But competitive disadvantages can occur in global markets due to different OELs, or implementation and control of regulation.

Example: fibre Laser processing (1µm wave length)

In Germany alone more than 5 R&D projects were publically funded to analyse risks from optical radiation and develop new , safe cabins for fabrication with this Laser sources. In contrast, in Asian countries machines are often operated open, almost on the street..




- European joining technology is leading on reduction of occupational exposures and improvement of occupational safety
- recent examples: electronically controlled short arc variants, 1micron Laser systems, extraction torches, ergonomic welding equipment, environmental friendly coatings, etc.
- This can become a global competitive advantage, if regulation could be better synchronised and aligned

# Challenge 3: Automation and Joining integration under Manufacturing 4.0

So far, joining is often perceived, developed and implemented as stand alone fabrication step.

In times of mass production this was probably an justifiable and economic solution.

With Manufacturing shifting to automation, mass customisation and cyber-physical systems, a technology which can not be integrated into the overall production chain will loose relevance.

If joining will not be integrated , the accelerated outsourcing can lead to a substantial loss of value generated by joining industry in Europe.

Needs:

- sensors enabling in-situ monitoring of joining process
- sensors enabling in-situ monitoring of quality of realised joint
- control systems capable to instantly adapt joining process parameters to optimum values (“robust processes”, “self-optimisation”, “learning systems”)
- avoidance or capture and elimination of all process emissions which jeopardise integration of joining into production chains
- joining technologies developed from concept stage already for integration, considering pre- and post-operations.

# Summary – “industrial challenges => impulses”

1. **Inter-coordinated R&D, certification and education**
   - e.g. rules for mandatory project participants and stakeholders depending on TRL

2. **Vision: “Zero emission Arc and Laser Joining” – *be bold, Joining in Europe depends on this !***
   - e.g. novel technologies which can disconnected filler material transfer from electrical arc, but without compromising productivity or robot compatibility
   - e.g. alliances with other platforms like Photonics (PPP) to solve the light radiation issues
   - e.g. development of global mechanisms to align harmonisation of OHS regulation

3. **In situ monitoring , controlling and adaptation for automation under Industry 4.0**
   - e.g. development of sensor systems for continuous process and quality diagnostic for data sampling and communication
   - e.g. use signals from in situ analysis for instant control of process to guarantee continuous operation at optimum parameters – will answer also mass customisation trend
   - e.g. develop Joining technologies as integrated part of production chains and not as “detachable” process – keep value generation in Europe. (link to Robotics PPP)

4. **Multi material mix and high-performance materials**
   - a main, important driver for R&D on Joining / subject of next industrial presentation




# Thank You for your attention.

Back-up

# G. Technology readiness levels (TRL)

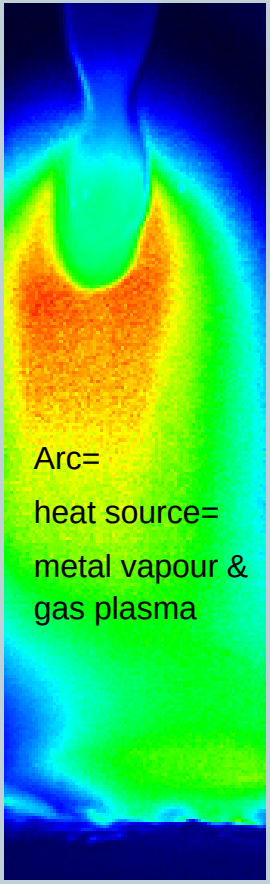
**Where a topic description refers to a TRL, the following definitions apply, unless otherwise specified:**

- **TRL 1 – basic principles observed**
- **TRL 2 – technology concept formulated**
- **TRL 3 – experimental proof of concept**
- **TRL 4 – technology validated in lab**
- **TRL 5 – technology validated in relevant environment (industrially relevant environment in the case of key enabling technologies)**
- **TRL 6 – technology demonstrated in relevant environment (industrially relevant environment in the case of key enabling technologies)**
- **TRL 7 – system prototype demonstration in operational environment**
- **TRL 8 – system complete and qualified**
- **TRL 9 – actual system proven in operational environment (competitive manufacturing in the case of key enabling technologies; or in space)**

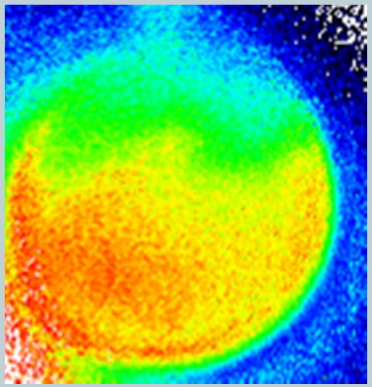
- **Source: HORIZON 2020 – WORK PROGRAMME 2014-2015; General Annexes, Page 1**

# Taking a closer look

**Anode: the melting filler**




~ 3,000° K
up to 95% of fumes



Detached droplet

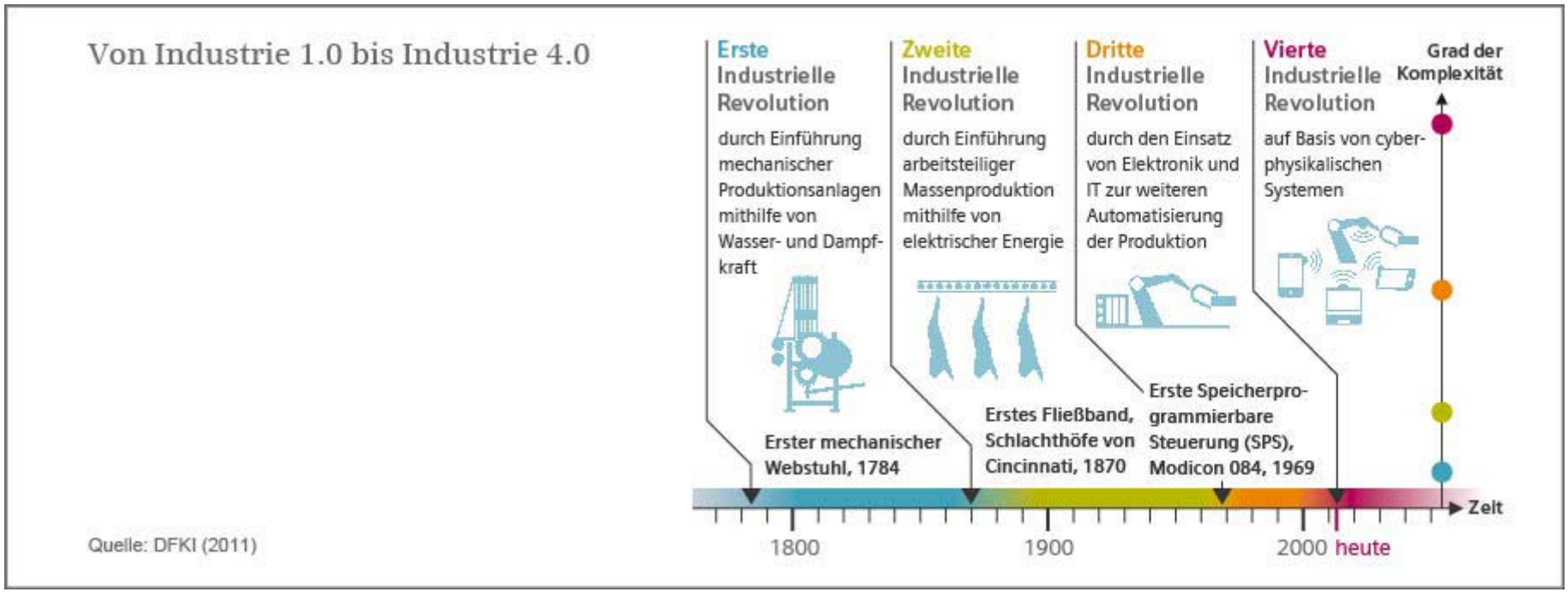
~ 1,800° K
up to 5% of fumes

**Cathode: molten pool/work piece**

- the original main source for particulate fumes is the filler electrode
- through the arc energy concentrated on this rather narrow anode surface, the filler is overheated, leading to excessive metal vapours
- depending on process variant – spray or pulsed arc – the detached droplets are exposed to additional heat crossing arc column on the way to the molten pool
- spectral analyses proved that arc plasma in MIG/MAG welding is predominantly metal vapour based, in alternation with Ar plasma during low current in pulsed processes or after short circuits
- avoidance of excessive metal vapours seems to be the only solution to significantly reduce fumes

Graphics based on : E. Siewert, Appl. Phys. D (2013)

# Industrialisation 4.0




Source: http://www.siemens.com/innovation/apps/pof_microsite/_pof-spring-2013/_html_de/industrie-40.html