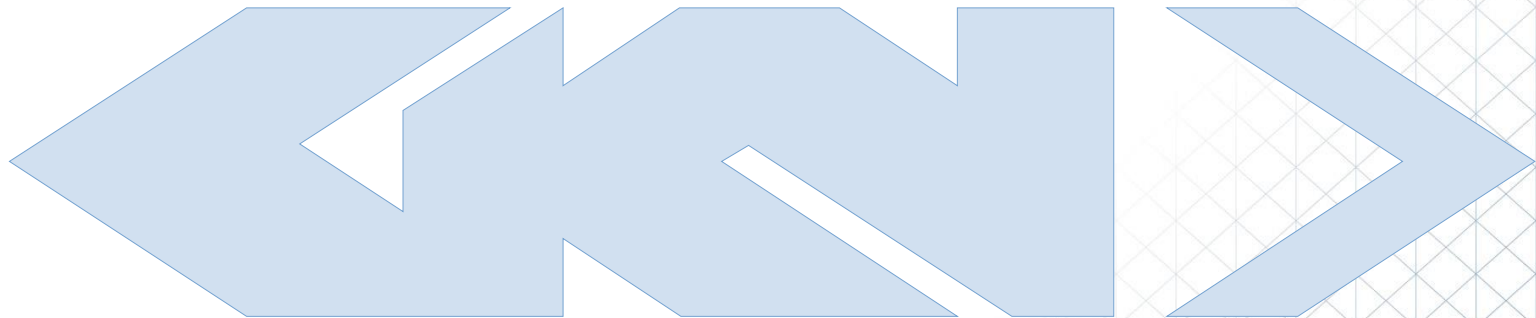


Laser Welding at GKN Aerospace Engine Systems

Achievements Challenges and Future, Supported by Research
Jimmy Johansson 2018-10-17/18



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GKN a Global Engineering group

Every day at GKN...



We drive the wheels of hundreds of millions of cars...



We help thousands of aircraft to fly...

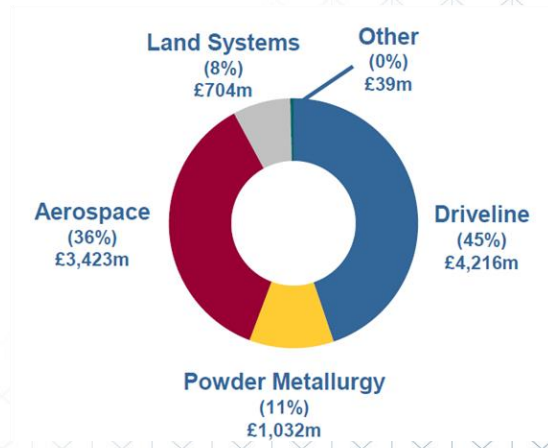


And we deliver the power to harvest crops and move earth.

In numbers

- > 58,000 employees
- > Locations in more than 30 countries
- > £9,4bn sales

Sales by division





A wide aerospace capability

AERO STRUCTURES



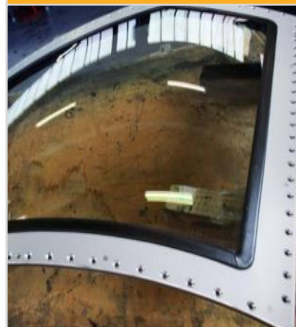
- > Fuselage, wing, nacelle & pylon
- > Inflight opening doors and empennage (tails)

ENGINE SYSTEMS



- > Static & rotating structures
- > Titanium engine inlet parts

SPECIAL PRODUCTS



- > Transparencyes
- > Ice protection systems
- > Flotation devices
- > Fuel tanks

WIRING INTERCONNECT SYSTEMS



- > Electrical Wiring Interconnection Systems (EWIS) for aircraft & aircraft engines

LANDING GEAR



- > Helicopter landing gear
- > Composite load carrying landing gear component

GLOBAL SERVICES



- > Availability services, MRO, conversion and completion for mature and legacy aircraft

GLOBAL NO. 2

GLOBAL NO. 2

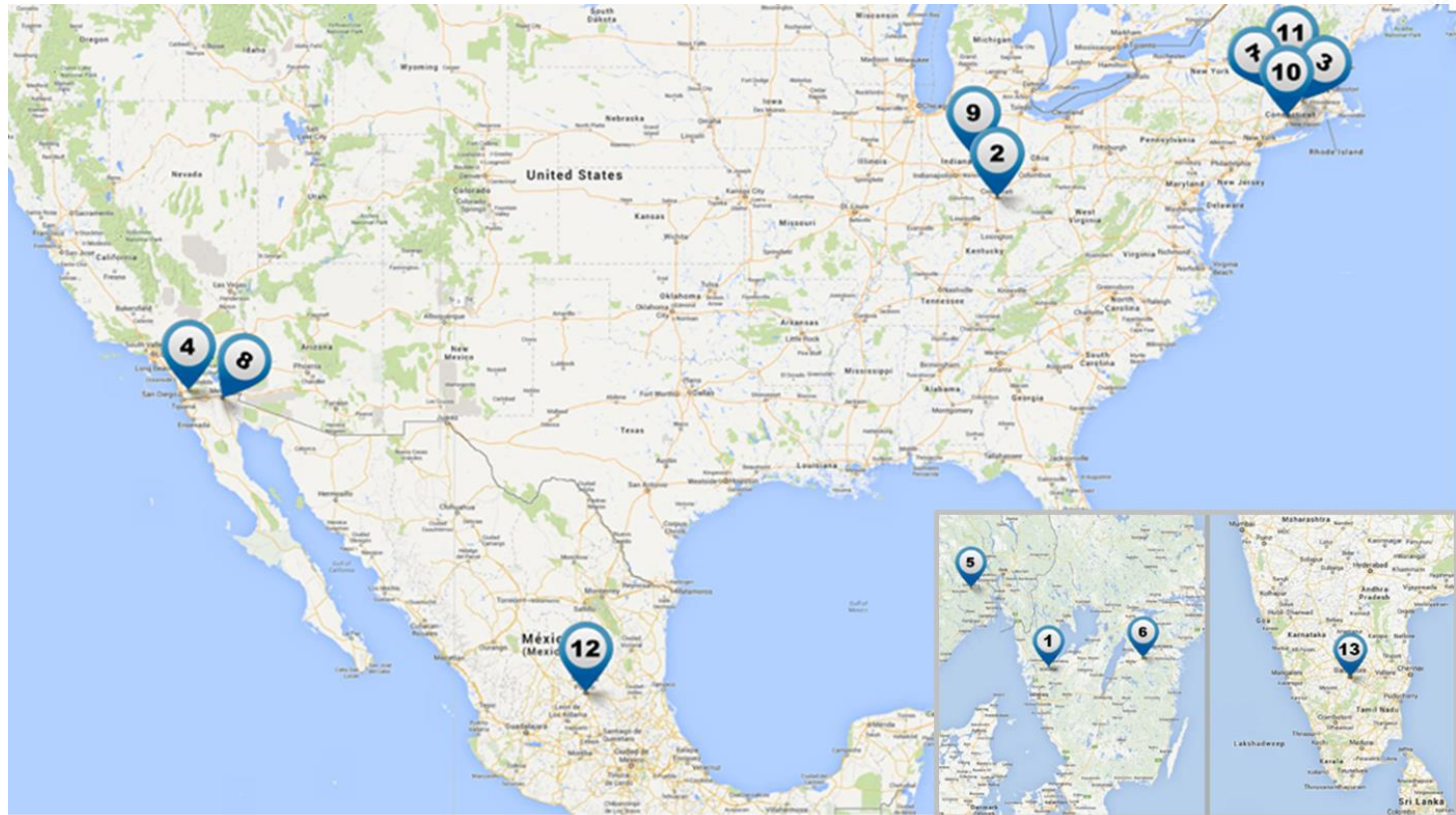
GLOBAL NO. 1

GLOBAL NO. 3

GLOBAL BRAND

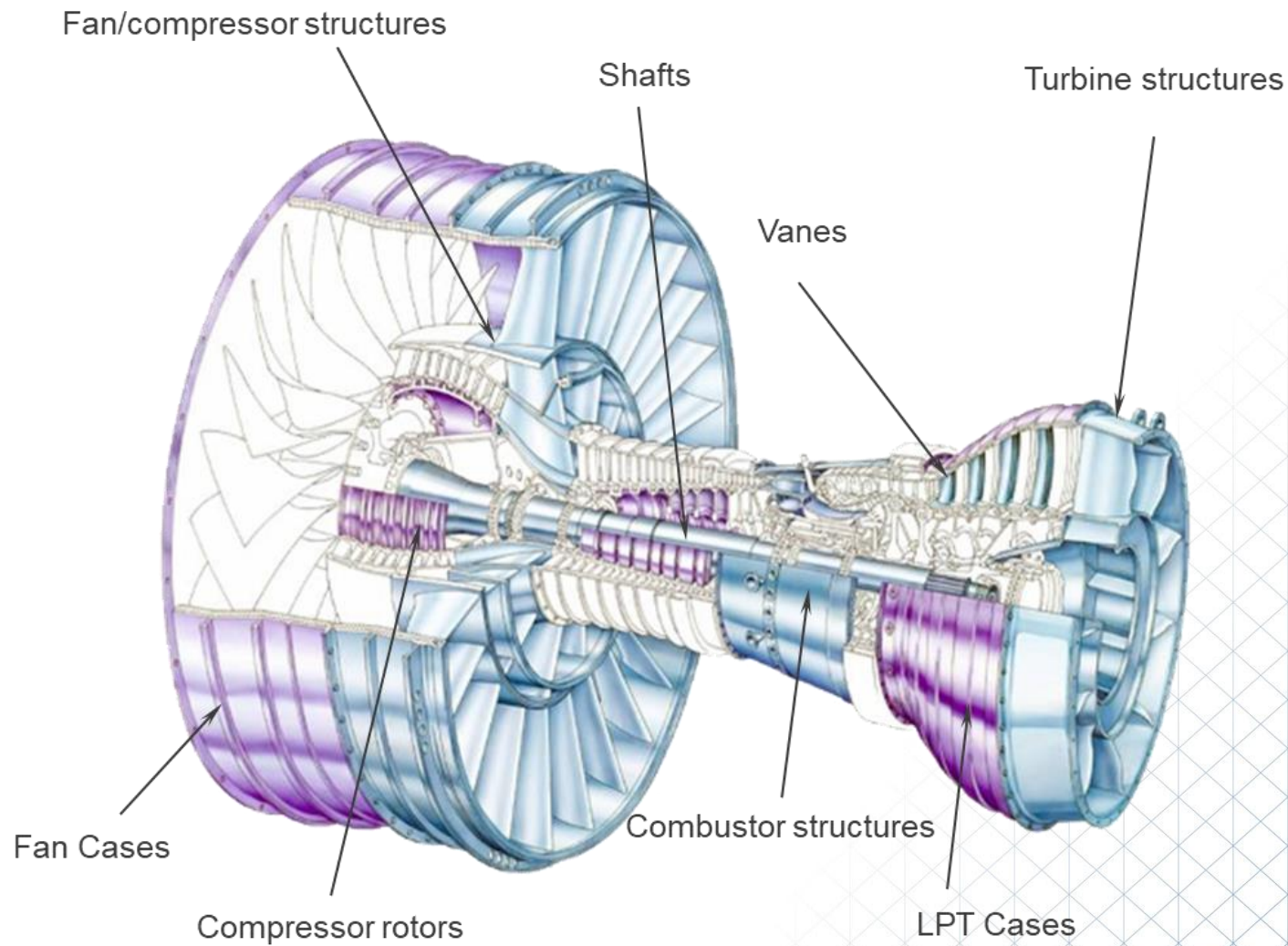
Aerospace Engine Systems

- 1 Trollhättan, SE (HQ AES)
- 2 Cincinnati, OH
- 3 Cromwell*, CT
- 4 El Cajon, CA
- 5 Kongsberg, NO
- 6 Linköping, SE
- 7 Manchester, CT
- 8 Mexicali, Mexico
- 9 Muncie, IN
- 10 Newington, CT
- 11 North Charlestown, NH
- 12 San Luis Potosi, Mexico
- 13 Bangalore, India



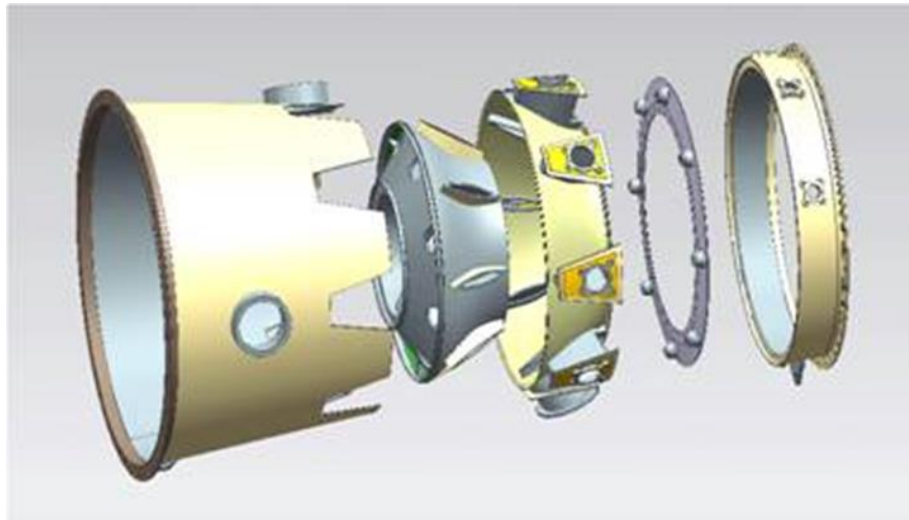


Our component specialisation



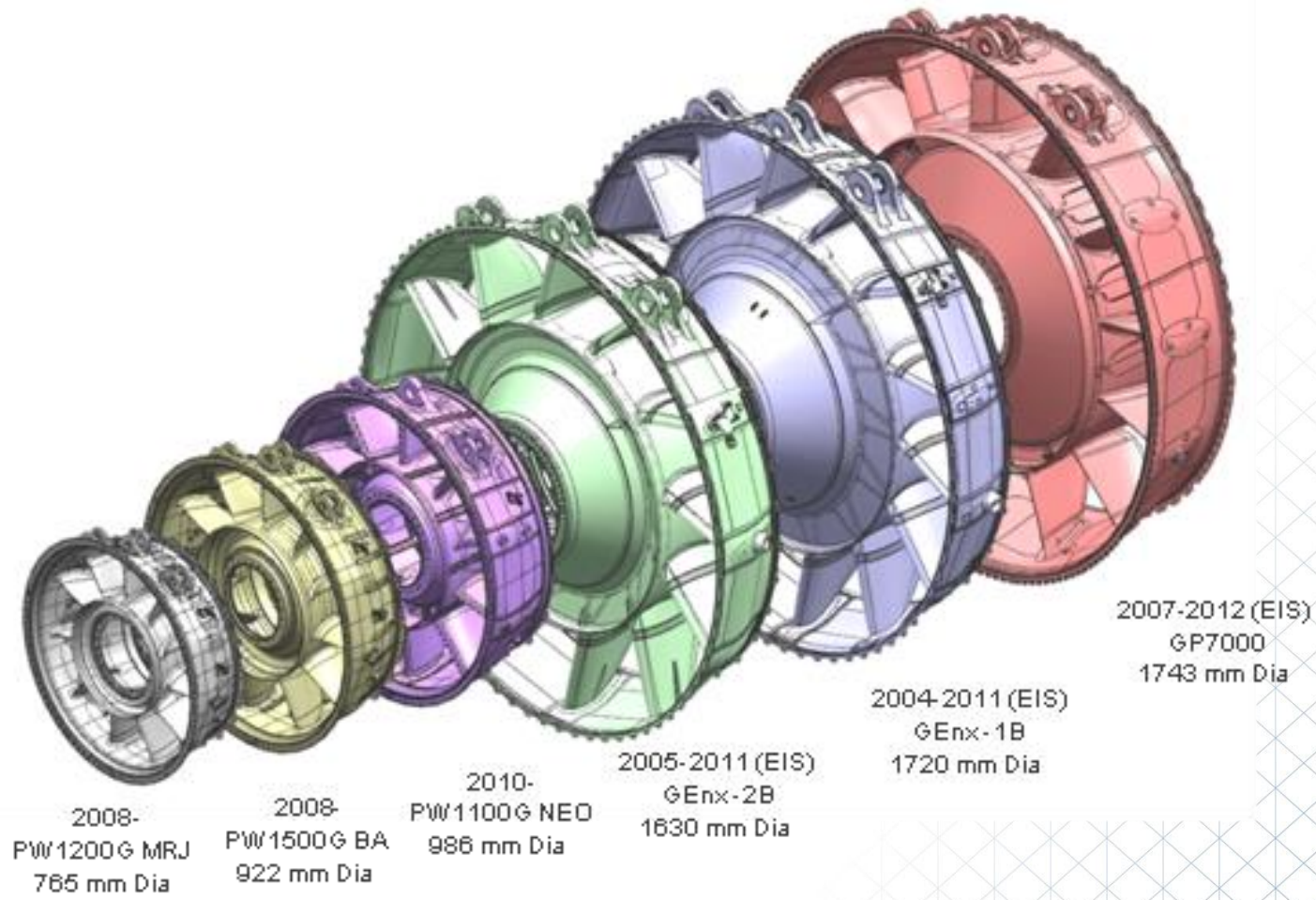
Background for laser welding development at GKN/VAC

- The focus concept "make it light", was the first major driver for a fabrication concept to manufacture structural jet engine components.
- The goal for this ideas was to reduce weight and having the design option of a graded property part.
- The fabrication concept also increased the cast work piece supplier flexibility.





Turbine Structures



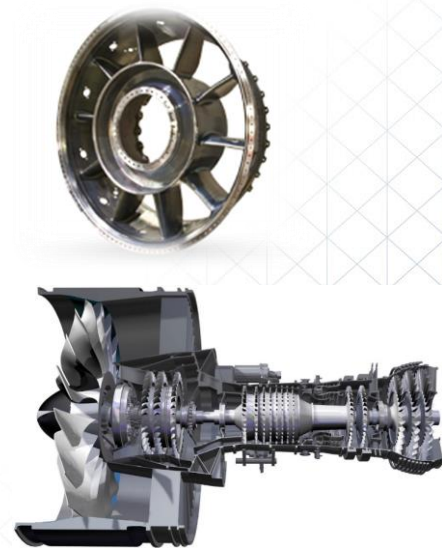
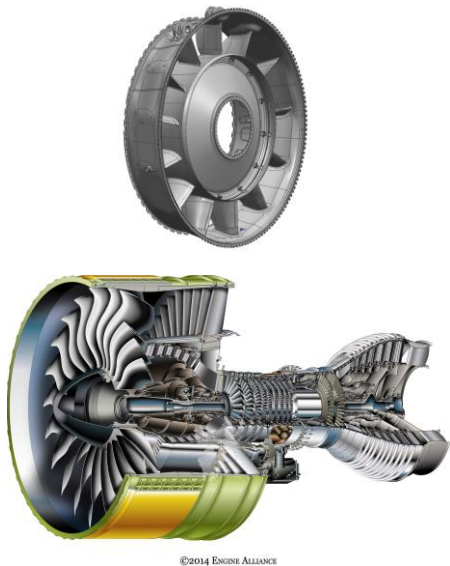


Fabricated structures by GKN

GP7000 TEC
Nickelbase Superalloy

RR Trent XWB ICC
Titanium Alloy

PW1000 30k TEC
Nickelbase Superalloy



A380

A350

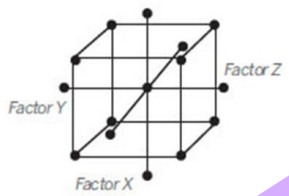
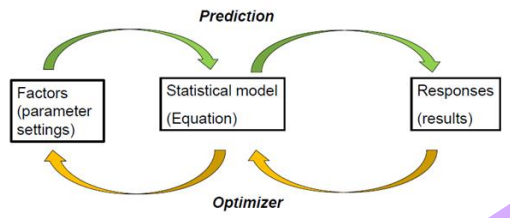
A320 NEO





Building knowledge for optimization and control

TRL/understanding



Process Development Chain

4.0 Communication

Automation

SPC

Part qualification

Verification

Optimization

Reduction of dimensions

Comparison

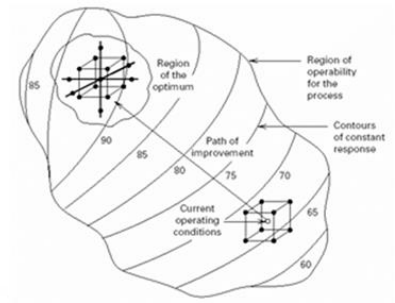
Variation

Variables

"Basic conditions"



MVDA Multivariate Data Analysis

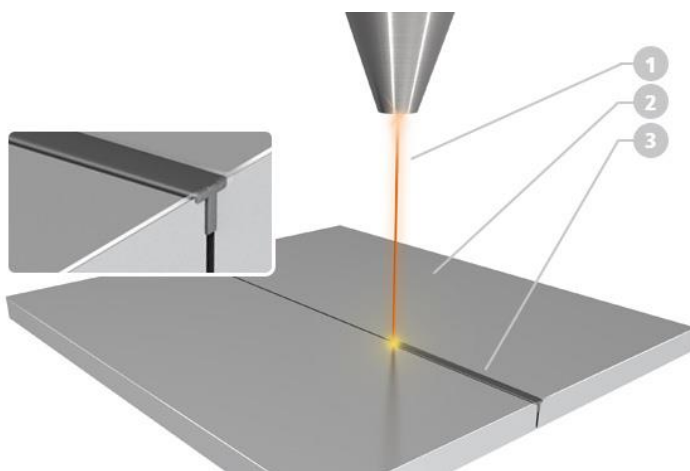


time

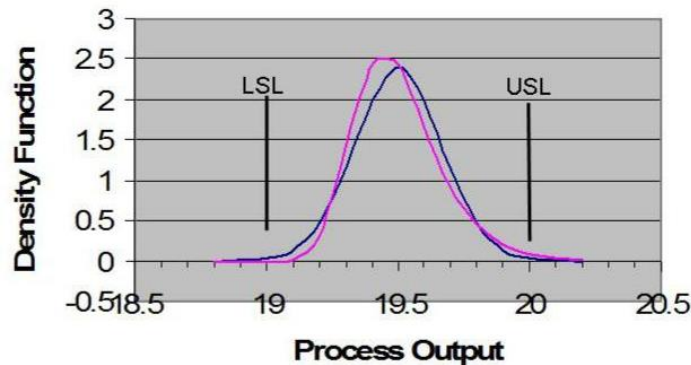
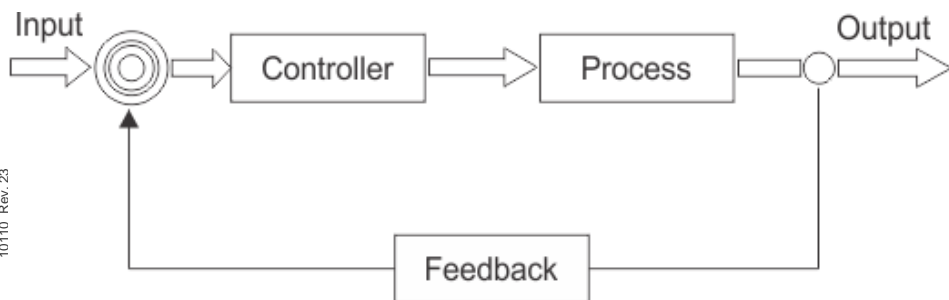
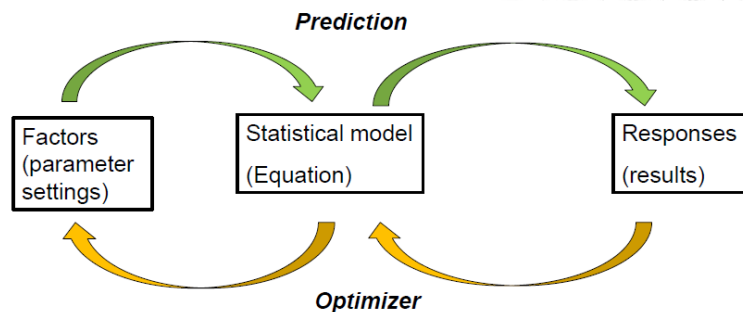
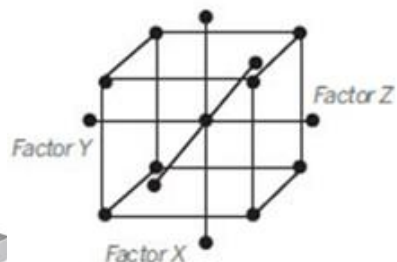


Building process knowledge by experiments

Manufacturing processes are multivariate problems, so a smart experimental strategy is a key to success.

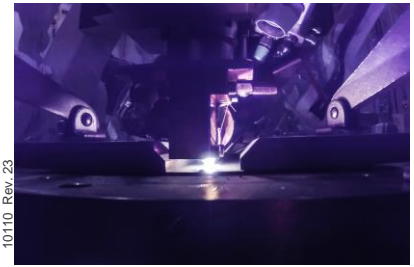
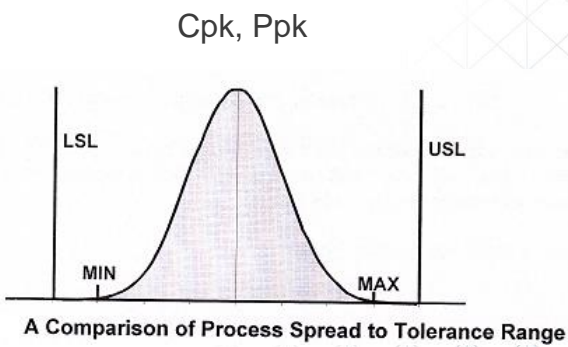
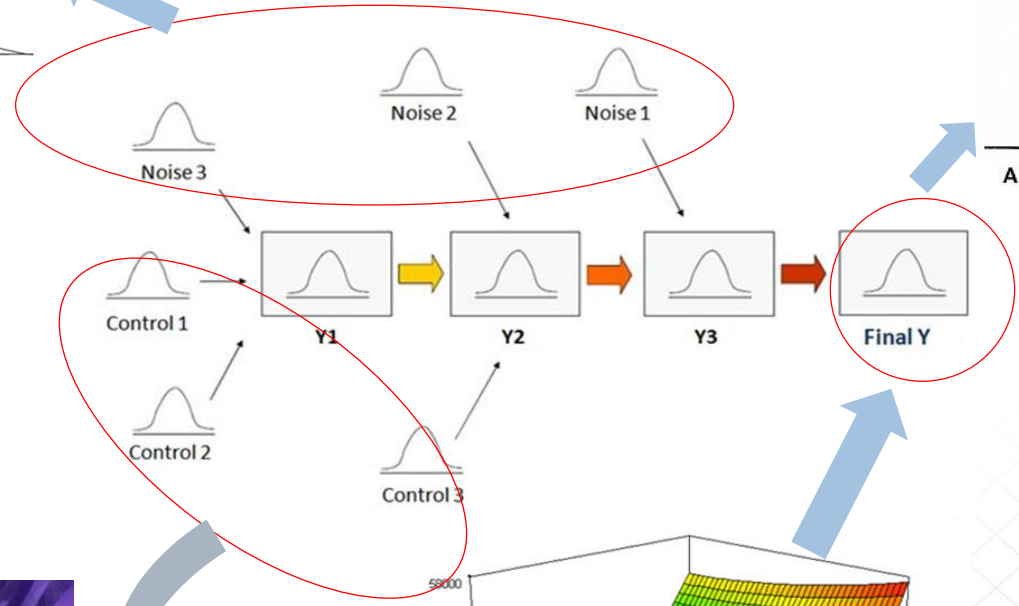
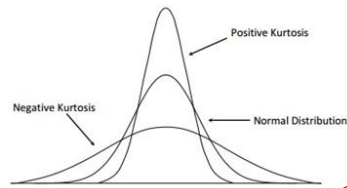


Experimental designs

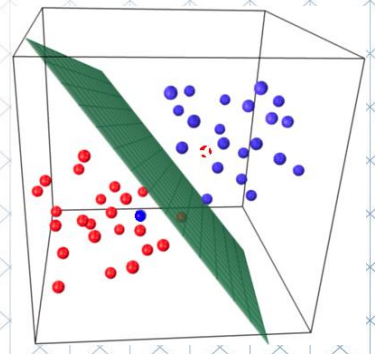
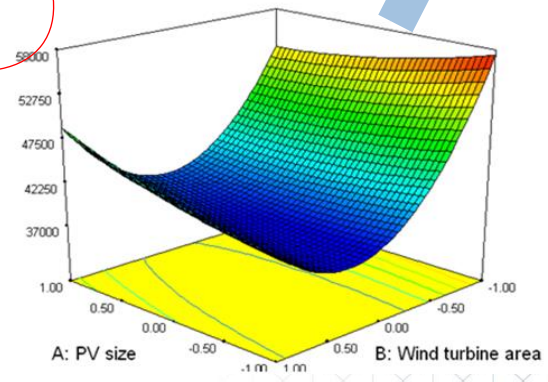




Process scatter, modelling and capability



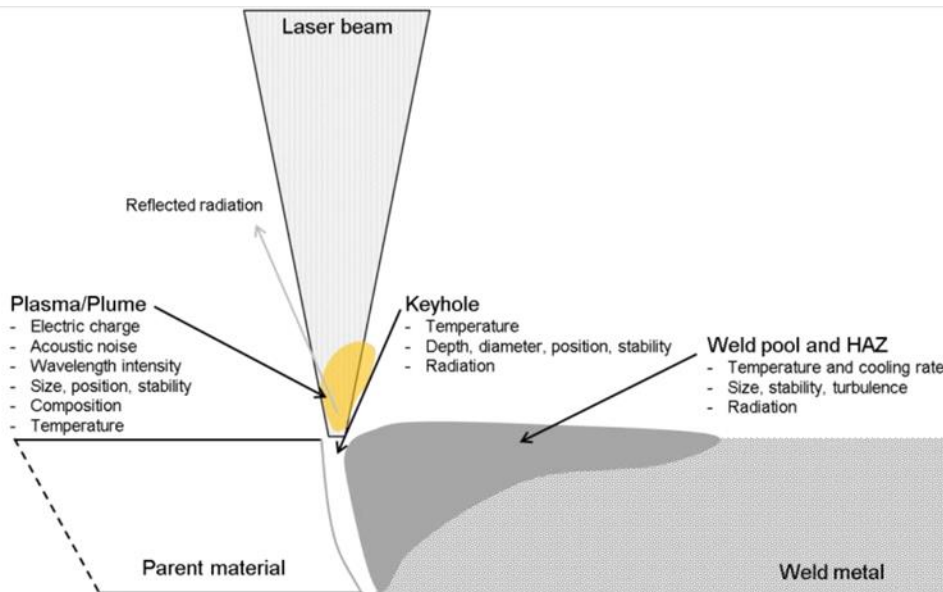
Response surface or Linear model



Categorisation of results vs variables

Challenge – Start/Stop and dynamic parameter sets

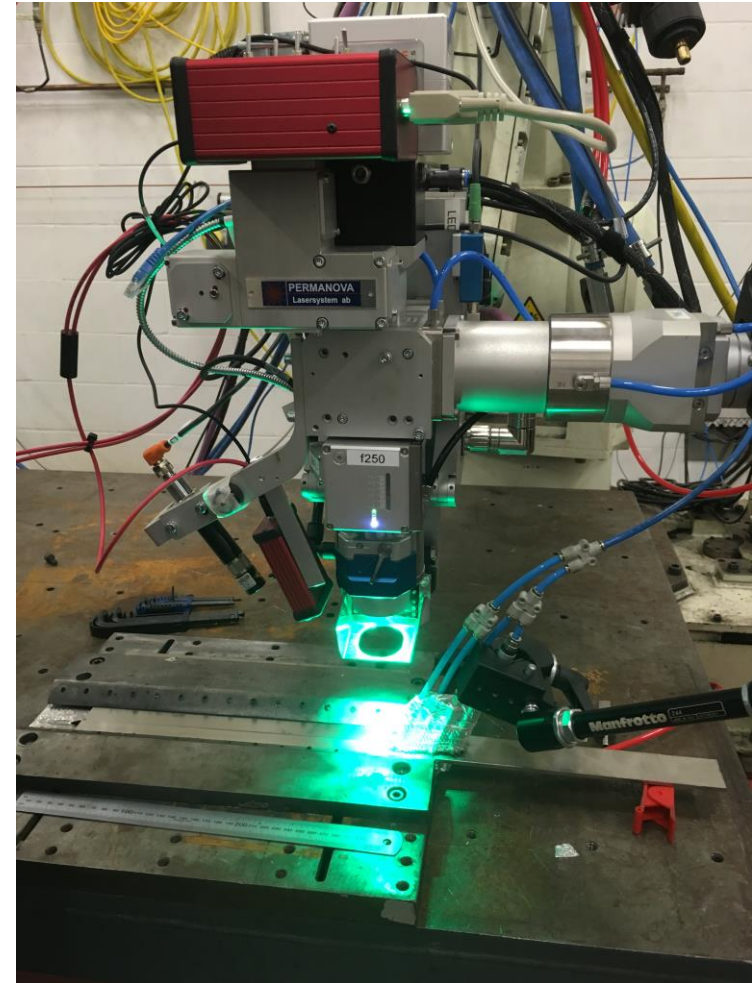
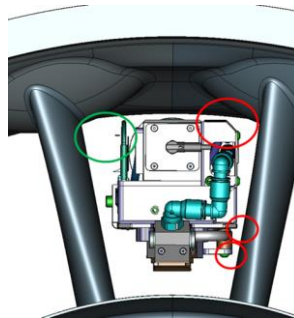
- Closing the welding key hole without trapping porosity or generating a bad geometry, is a delicate task with a long list of potential control variables.
- Curvature, welding with an angle, around corners and thickness variations are difficult parts as well.



Adding sensors to the process to record process changes has a good potential, still most of them will act as a monitoring tool, and not as a signal for in-process control. The **Radicle** project has contributed with another step to reach in-process control.

Challenge – apply sensors on tooling

Access vs process monitoring and control
Energy management in small spaces

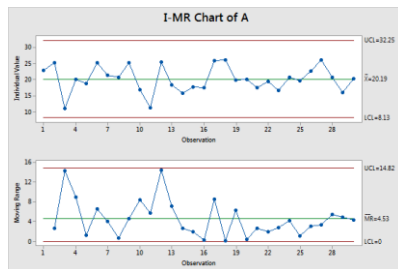


Challenge – Monitoring and Process Control, supported by Radicle results

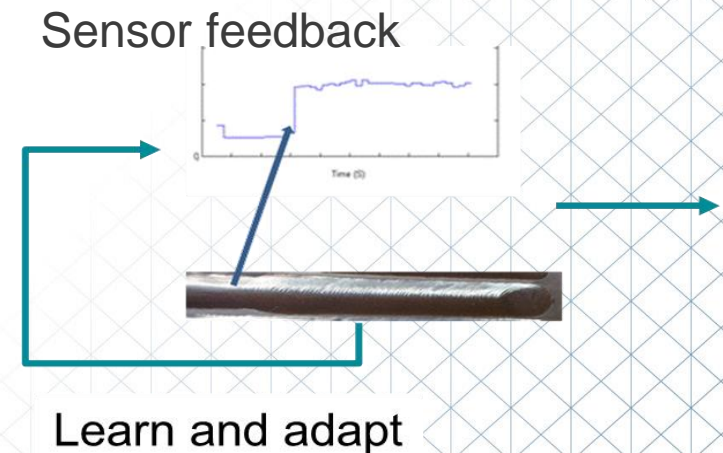
What can be made **before**, **during** and **after** each weld joint to make sure that the weld joint properties fulfills the requirements ?

- There is a strong connection to the learnings from the structured mapping and optimization earlier in the development process.
- Key process features for SPC, and closed loops, followed by the quality assurance data attached to the joint and product.
- What data shall be saved and how accurate does it need to be, regarding for example geometry ?

1



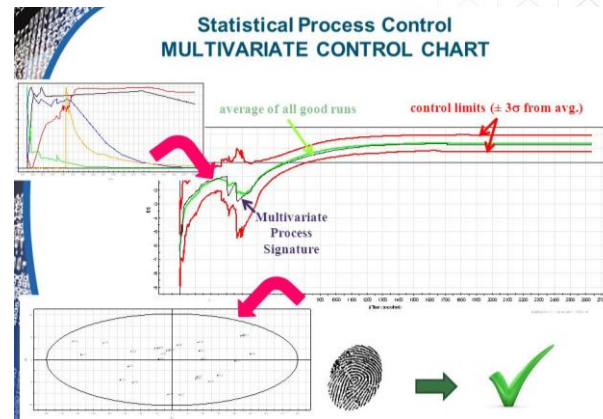
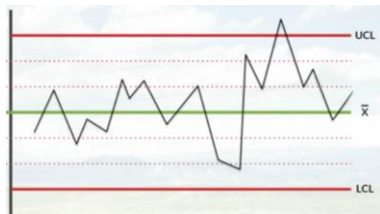
2



Preparing for Automation and 4.0 systems

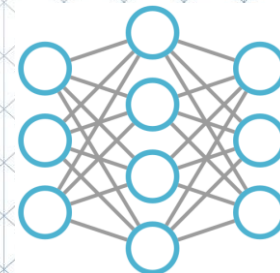
Information generated in the process development phase to be used again

- Go/No Go systems
- Key process variables
- Key features for quality
- Sensor data
- Production data



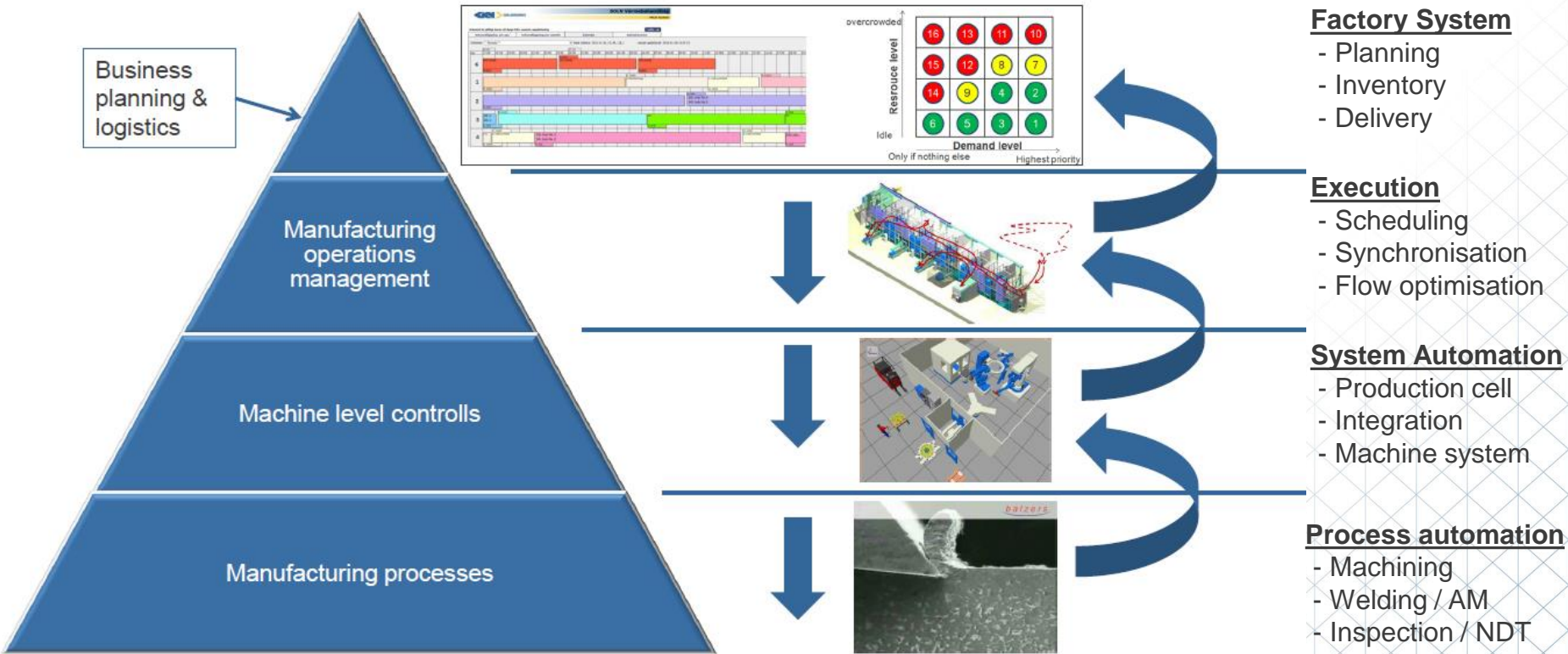
SPC

Machine learning

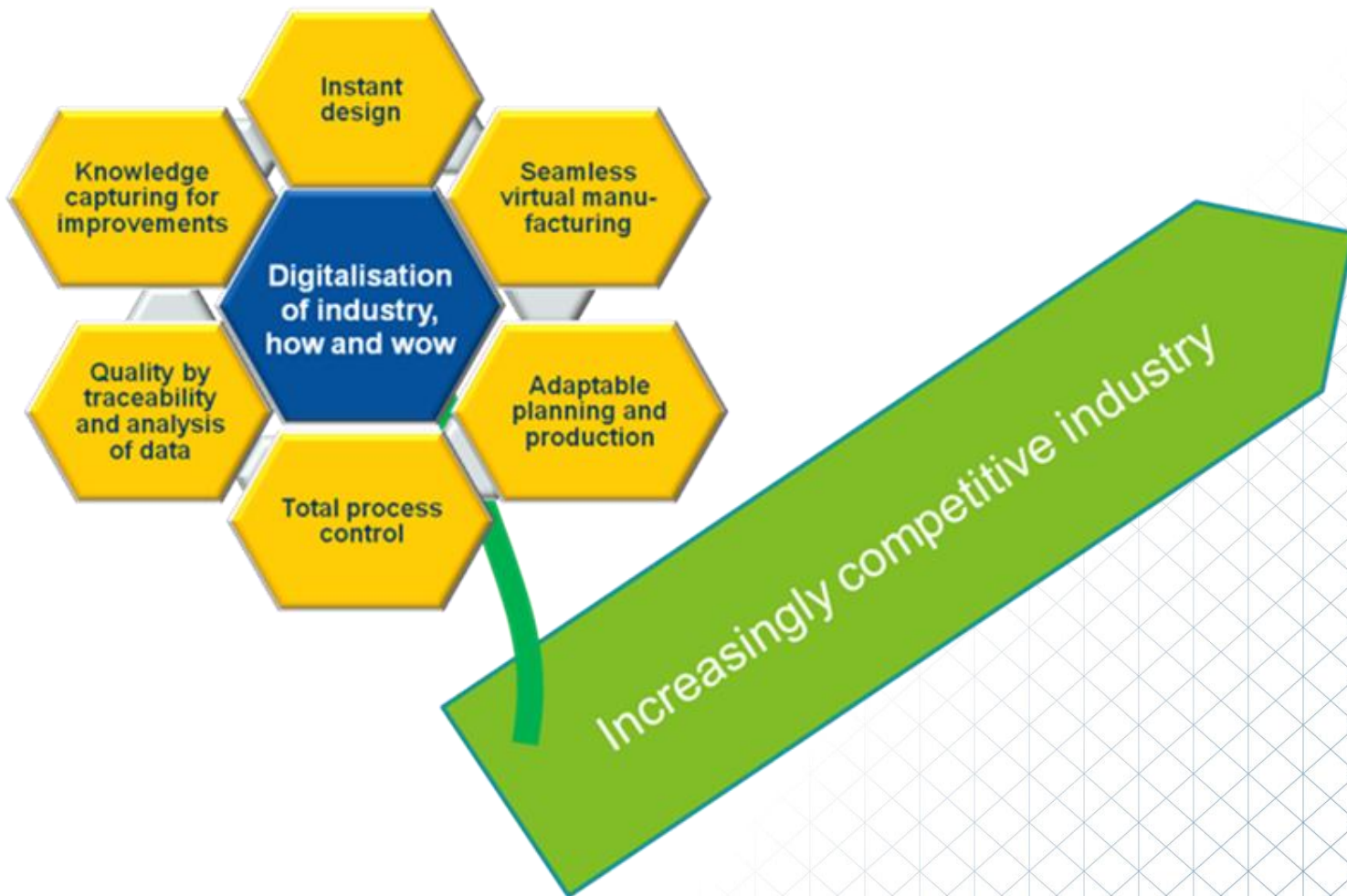




Industry 4.0 Activities at different levels



On process level:
 What will be the required information to feed into the welding process and what information should be fed from the welding process ?





Thank you for your attention !