

Industrialization process

**Power couplers for XFEL project
as an example**

Industrialization: Why ?

Start: Prototypes
(30 Couplers)

Industrialization
process

End: Large series
(1000 Couplers)

Quality:

- uneven
- random anomalies

Manufacturing:

- long and difficult
- lack of procedure
- only a few people have the competence

High cost

Quality:

- equal for all items
- reliable

Manufacturing:

- regular process
- written procedures
- standard competence

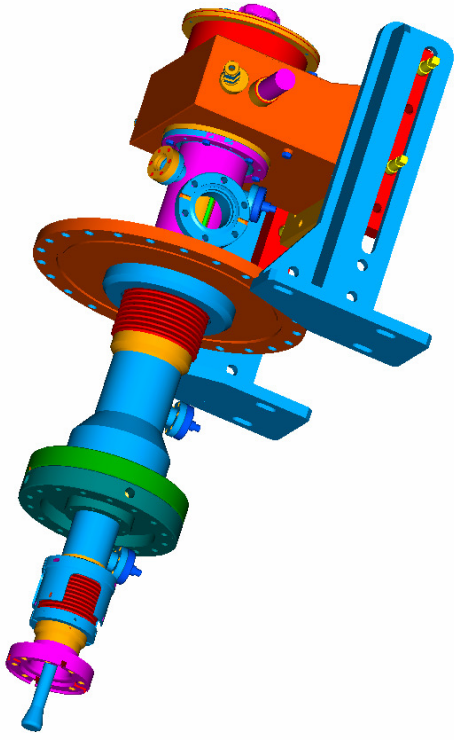
Lower cost

Industrialization: What for ?

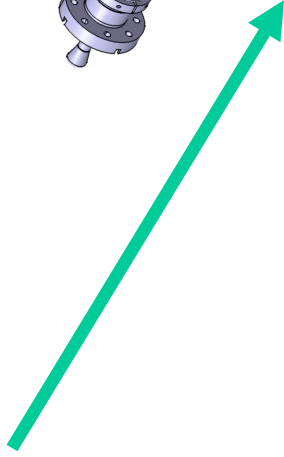
Objectives:

1. To improve the quality
2. To define precisely:
 - all manufacturing processes
 - the control plan for quality assurance
 - the necessary equipment
 - the competences and the people
 - the manufacturing sequences
 - the schedule
 - the room space needed for all steps
 - the **costs**
 - the **risks** (technical, of procurement, financial)
3. To reduce the manufacturing costs

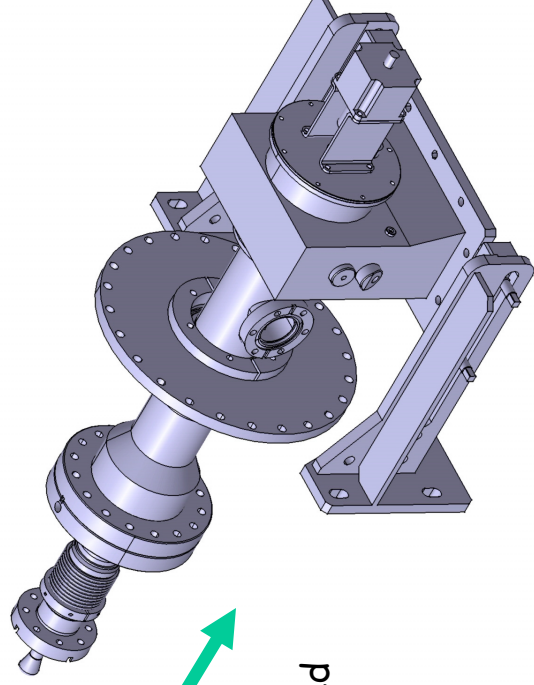
Before industrialization: specifications changes



TTF-3 Coupler



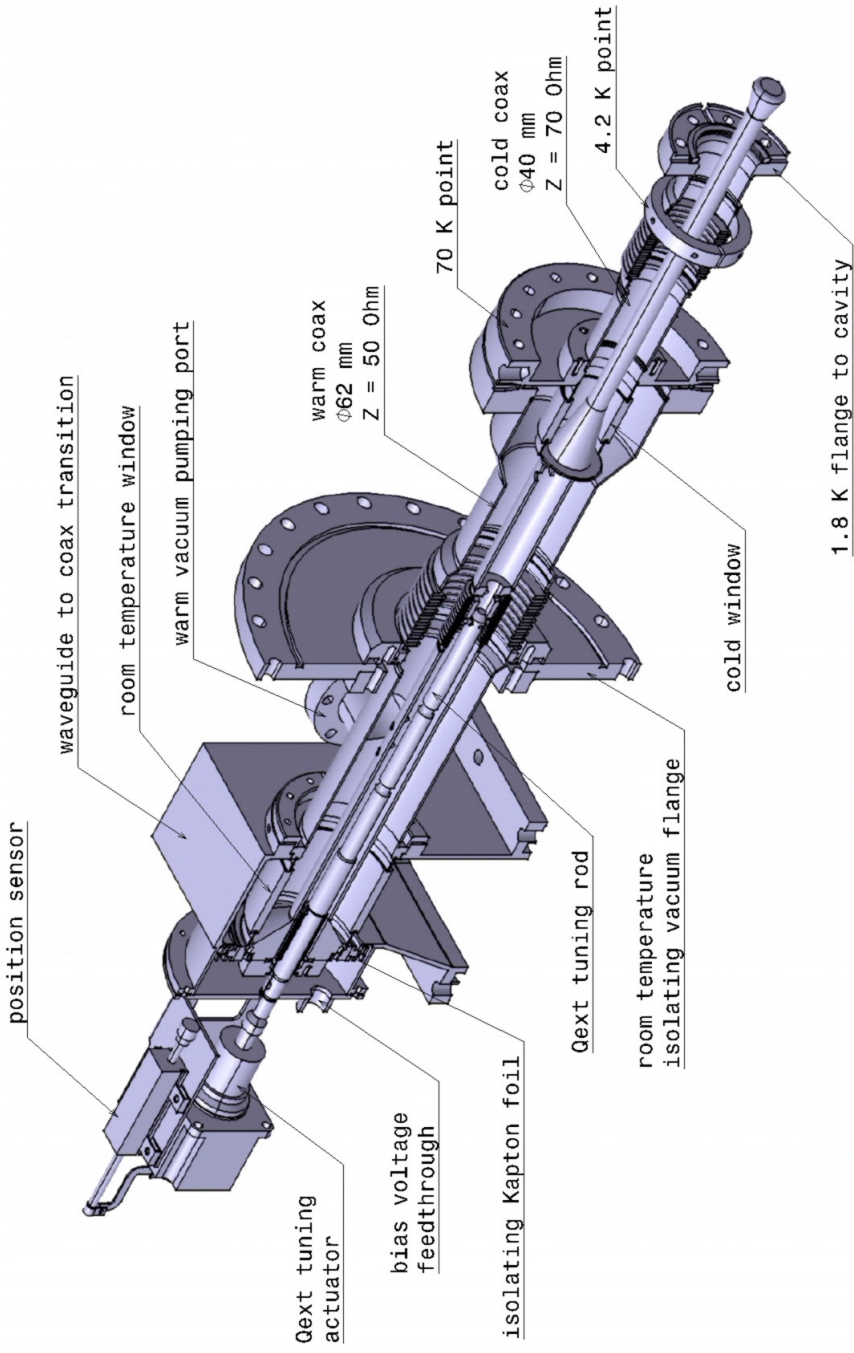
- 4 diagnostics removed
- motorized tuning



XFEL Coupler

Before industrialization: final design

X-FEL coupler



→ Review drawings of each component in terms of tolerances



Analysis of each function results in:

- options for design
- options for material
- options for geometry
- options for components junctions

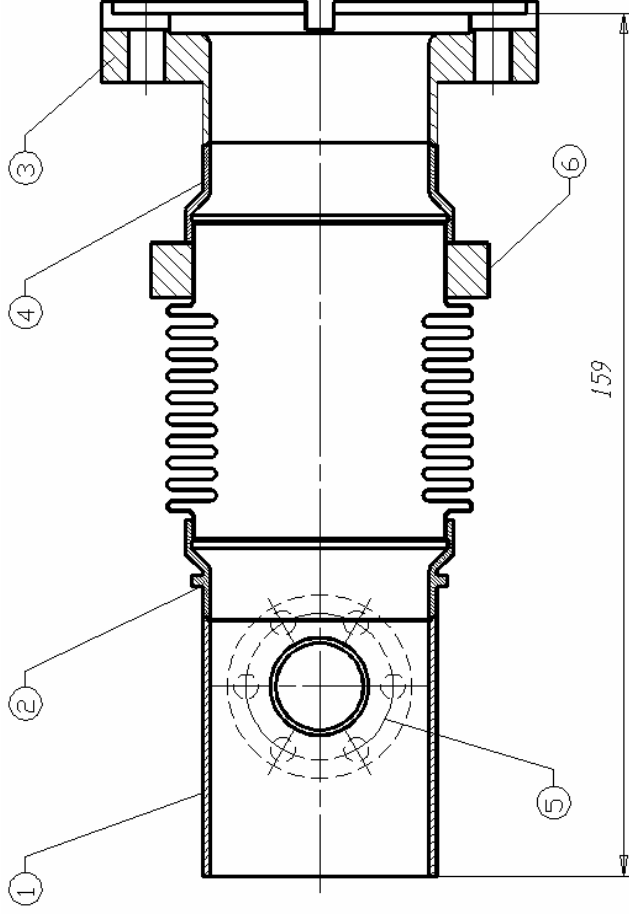
Each options has to be investigated in terms of:

- performance compatibility
- feasibility
- availability
- cost

Identify cost reductions by component - 3 -

→ **Simplify concept**

Example: Cold external conductor



Present design: bellows collars are machined + welded to standard bellows
Alternative: bellows including special collars are hydroformed together in 1 part

Industrialization: Topics of development -1-

→ Design for « manufacturability »

- Review existing design
- Identify the necessary functions
- Determine maximum acceptable tolerances
- Identify possible options for design
- Seek functional simplicity :
 - to minimise the number of parts
 - use standard products whenever possible
 - design for ease of assembly: several assembly solutions are possible, investigate and optimise
 - design for ease of control and test
 - design in view of packing and transport

Industrialization: Topics of development -2-

- Risk mitigation:
 - Assessment and re-design of areas of technical and process risk
 - Generation of product and process specifications
 - Update design
- Validation phase:
 - Modelling of component and process
 - Testing
 - Prototypes
 - Update design
- Other design topics to be considered:
 - reliability (of components, welds, coatings)
 - other risks (of procurement, logistics, financial)
 - MTBF, failure analysis (welds, windows, motions)
 - maintainability (easiness of replacement)
 - ergonomics (handling, assembly)

Industrialization: Check ?

→ Iterative process after every change

Verification phase

Several possible new designs result from the functional analysis:

- Verify that the desired specifications are fulfilled
- Check the coherence of interfaces
- Produce prototypes
- Follow a test program
- Analyze the results
- Corrective actions if necessary
- Decide on the final solution
- Finalize Manufacturing Control Plan

For the XFEL power couplers, industrialization studies will be performed through "Definition contracts" :

- Essentially intellectual work (in dialog between the industry and our Lab) :
 - Define all manufacturing processes (analysis and validation models)
 - Risk analysis (process, logistics)
 - Determine cost in series and justify
- Produce 2 prototypes (to be tested at LAL - Orsay)

Particularities

- 3 contracts will be awarded on the same subject: « Industrial studies »
- 2 teams will be selected after final evaluation
- contracts for manufacturing 2 series of 500 XFEL couplers will be awarded without a new call for tenders
- the 2 contracts may be awarded to a single company

Follow-up and evaluation of definition contracts

1. Continuous evaluation of performance
 - contracts will run simultaneously during 21 months
 - Regular progress reports
 - Continuous control of industry activity

2. Formal reviews are key points with delivery of documents, models and prototypes
 - SDR (System Design Review)
 - PDR (Preliminary Design Review)
 - CDR (Critical Design Review)
 - Final Review

Keypoints of the definition contracts

Contract Award: T_0

Kickoff meeting: soon after T_0

System Design Review: $T_0 + 3$ months

- functional analysis
- identification of processes and proposal for models
- preliminary development plan, management plan

Preliminary Design Review: $T_0 + 8$ months

- models for welding, brazing, specific materials, Cu coating
- Quality assurance plan
- development plan, management plan
- Technical design review
- preliminary risk analysis

Critical Design Review: $T_0 + 14$ months

- final models for validation of Cu coating
- final justification design file
- final risk analysis
- preliminary cost analysis

Final Review: $T_0 + 21$ months

- delivery of 2 prototypes
- plan for logistics of manufacturing and conditioning
- final cost report

Deliverables for the definition contracts

1 - Technical reports:

spread over 3 intermediate reviews (see time schedule)

- Conduct and comment all **studies** necessary for the fabrication of couplers, including TiN deposit
- Determine and explain the manufacturing **processes**, provide **models** for validation of each process
- Finalize and justify the mechanical **design** in view of lower cost in series and shorter time of assembly, evaluate risks
- Define and comment the sequences of **assembly** and **conditioning** of couplers, estimate time for assembly sequences
- Determine and comment the manufacturing **logistics** (in manpower, in building area) including conditioning, and evaluate difficulties and risks
- Establish a project **management plan** for the manufacturing in series:
 - . PBS, WBS
 - . interfaces
 - . Cost control, time schedule control
 - . Management of changes
 - . Quality assurance
 - . Risk management
 - . Documentation control
- Establish a manufacturing **schedule** including conditioning and delivery

2 - Deliver validation models and 2 prototypes:

- models to validate each manufacturing process (welding, brazing, spinning, Cu coating, ...)
- 2 prototypes assembled on test stand ready for conditioning:
 - already cleaned, baked, assembled, vacuum pumped and leak tested

3 - Financial report:

Objective: → *Commitment to a unit price in series, for 500 and for 1000 couplers*

- Fill out a detailed price list including manufacturing, assembly and HF conditioning (Klystrons and modulators could be provided by the XFEL project), packing and transport on site
- Deliver a detailed report on price justification analysis