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THALES experience for EU-XFEL project

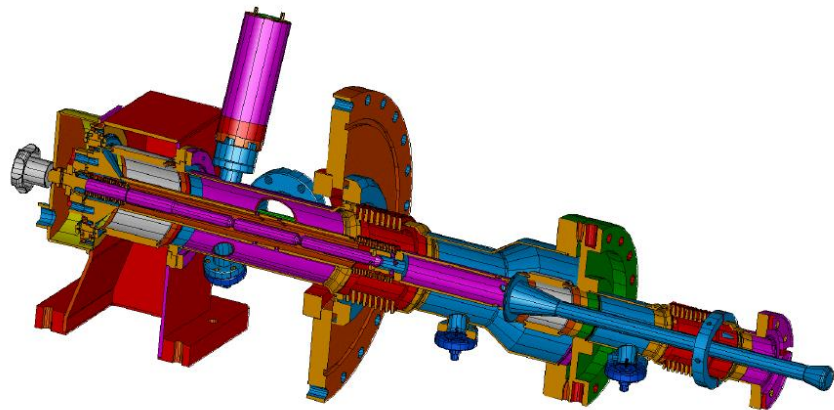
From the (non-)pre-industrialization phase to mass production

FEB 5TH, 2019

www.thalesgroup.com/en/markets/market-specific-solutions/microwave-imaging-sub-systems

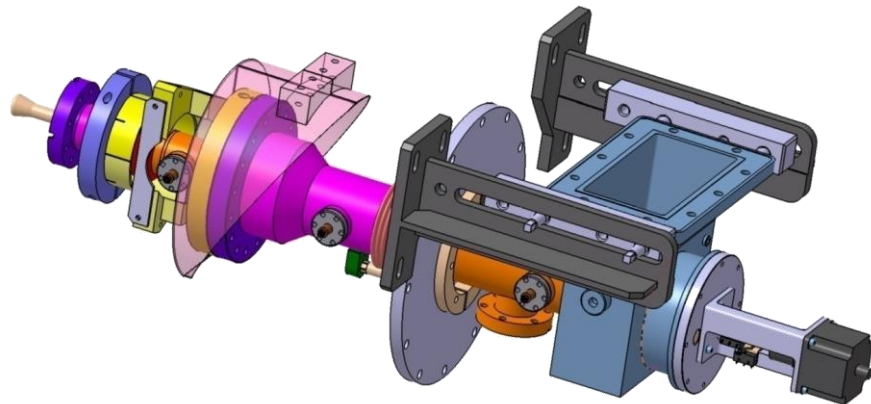
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TTF3 Coupler operated on FLASH

- Safely operated from 2000-2005 at DESY
- Fabricated in medium size quantity (<100 PCES)
- Performances (400kW / 5kW)
- Reference price ~25kEUR



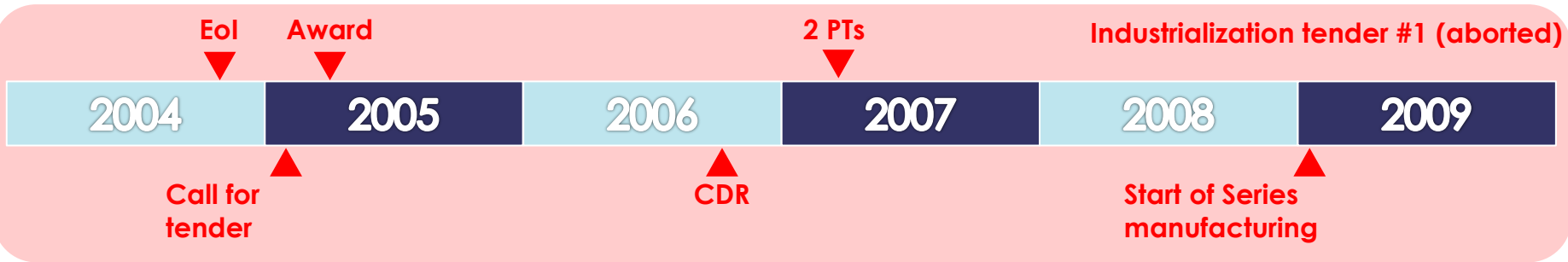
EU-XFEL Coupler

- LAL / DESY collaboration: Design changes from TTF3 (less diagnostic ports, motorized tuning, relaxed axial tolerances)
- Performances (150kW / 1,95kW)
- To be produced in mass (820 PCES) with price reduction expected (-60% compared to TTF3)

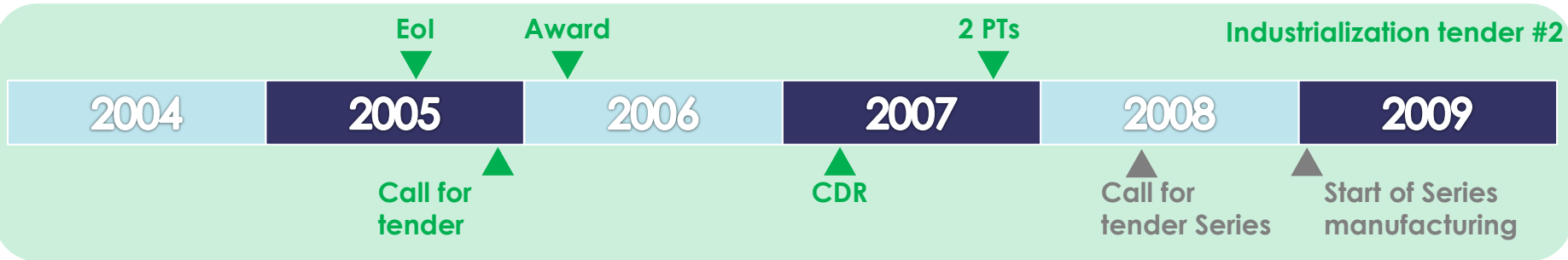
Launch of an industrialization phase to reach prices and delivery targets with high QA

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Industrialization tenders | two attempts due to regulation changes



➤ Change of EU tendering rules with no possible commitment on Series to selected firms



➤ Three firms successfully awarded for tender #2: E2V, TOSHIBA and RI (formerly ACCEL)

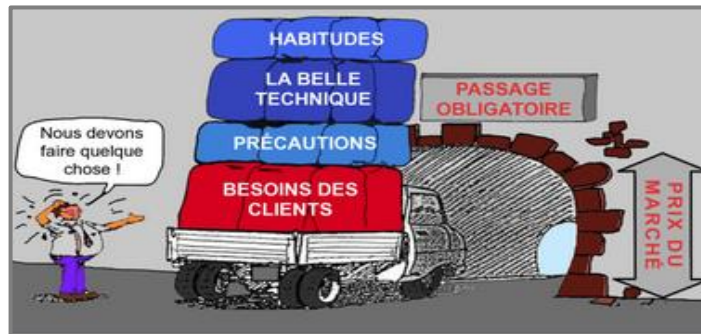
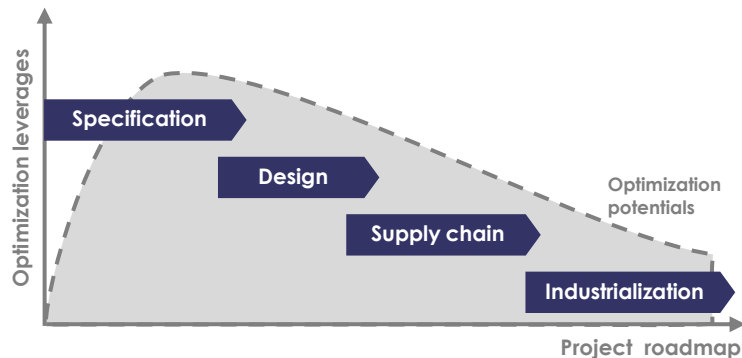
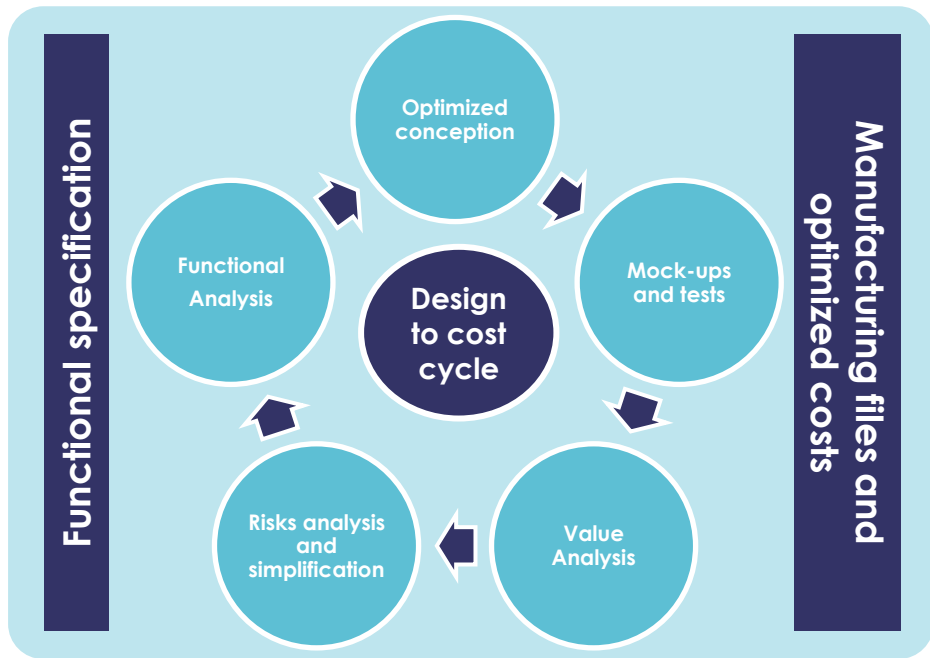
- Good level of documentation shared to IN2P3 and DESY
- French financial support per firm for the industrialization phase / prototyping : 250k€

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EU-XFEL coupler industrialization | From theory to practice

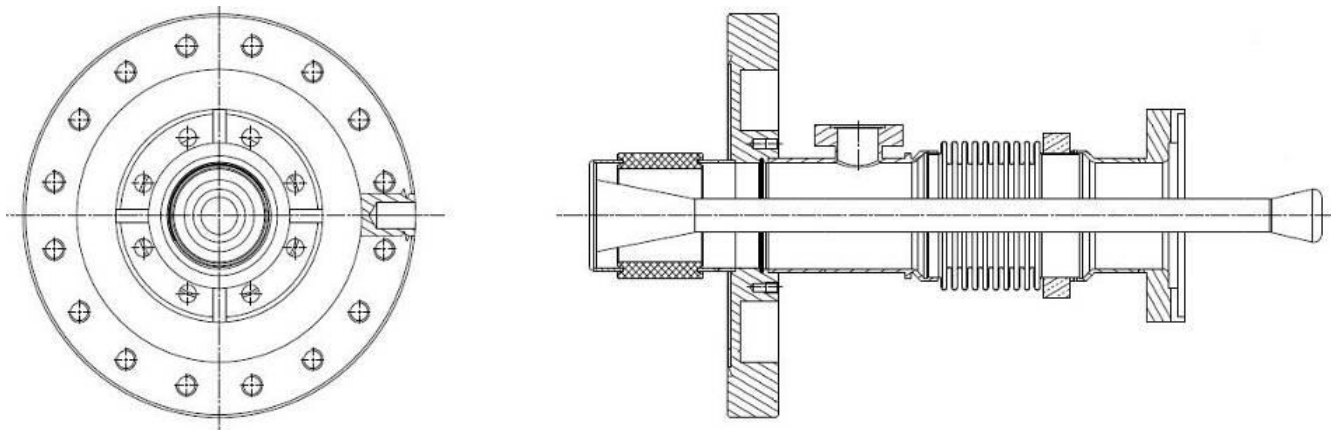
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Costs reductions reach limitations when “Design to Cost” actions are not fully integrated at the early stage of development. Usually, conception phase is mostly driven by existing State of the Art, search for perfection & high end engineering, with limited room to challenge technical specification.

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Example #1 (Cold external conductor and antenna)



TTF3 Solution

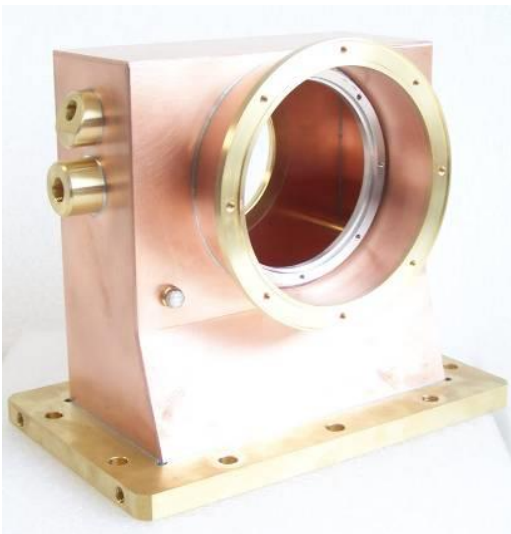
- The antenna is made with bulk OFHC copper
- Thermal cycling shall not exceed 250°C

Industrialization proposal

- Hollow stainless steel antenna with copper coating and end parts brazing
- Rejected due to cleansing, baking and pumping issues / TiN coating degradation

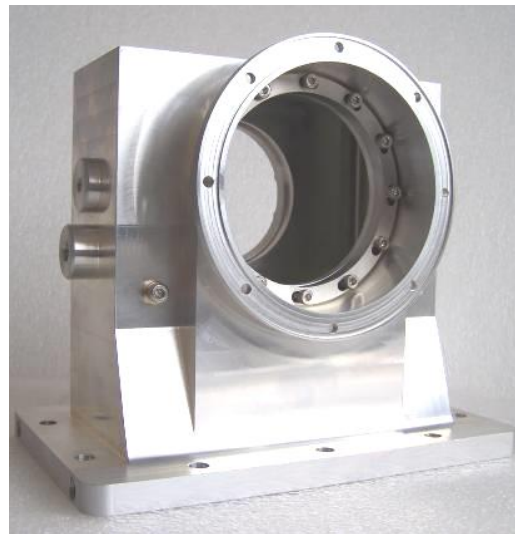
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Example #2 (Waveguide box)



TTF3 Solution

- Assembly / brazing of copper, brass and stainless steel parts
- RF contact ensured by copper membrane



Industrialization proposal

- Bulk Aluminum piece part machined with no brazing or welding phases
- Not considered due to high risks on RF contacts

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Example #3 (Ceramics assembly)



TTF3 Solution

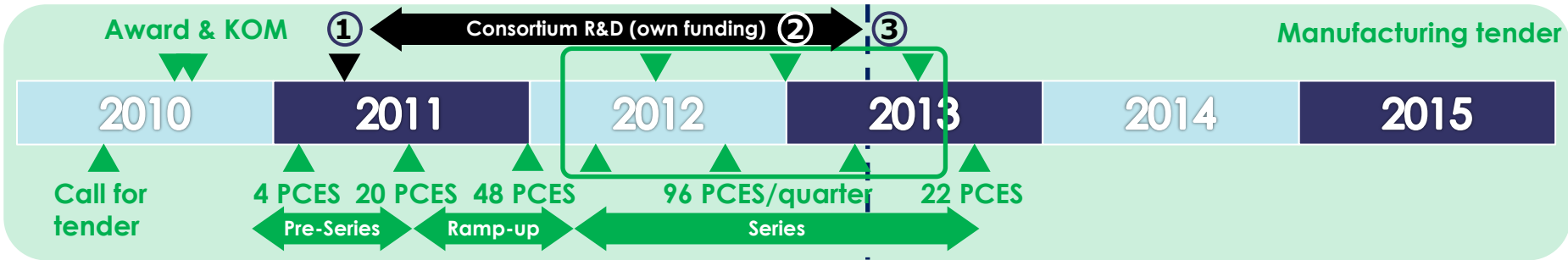
- E-beam welding of copper parts on ceramics

Industrialization proposal

- Brazing of final assembly
- Rejected due to TiN coating diffusion on ceramics / multipactor occurrence risks

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Series manufacturing tender | THALES experience



THALES activity

- Manufacturing of WIC, WEC, CEC and antenna
- Brazing of above critical parts assemblies
- Low RRR copper plating
- Tier #1 & Prime contractor w/ IN2P3 (program mgt)

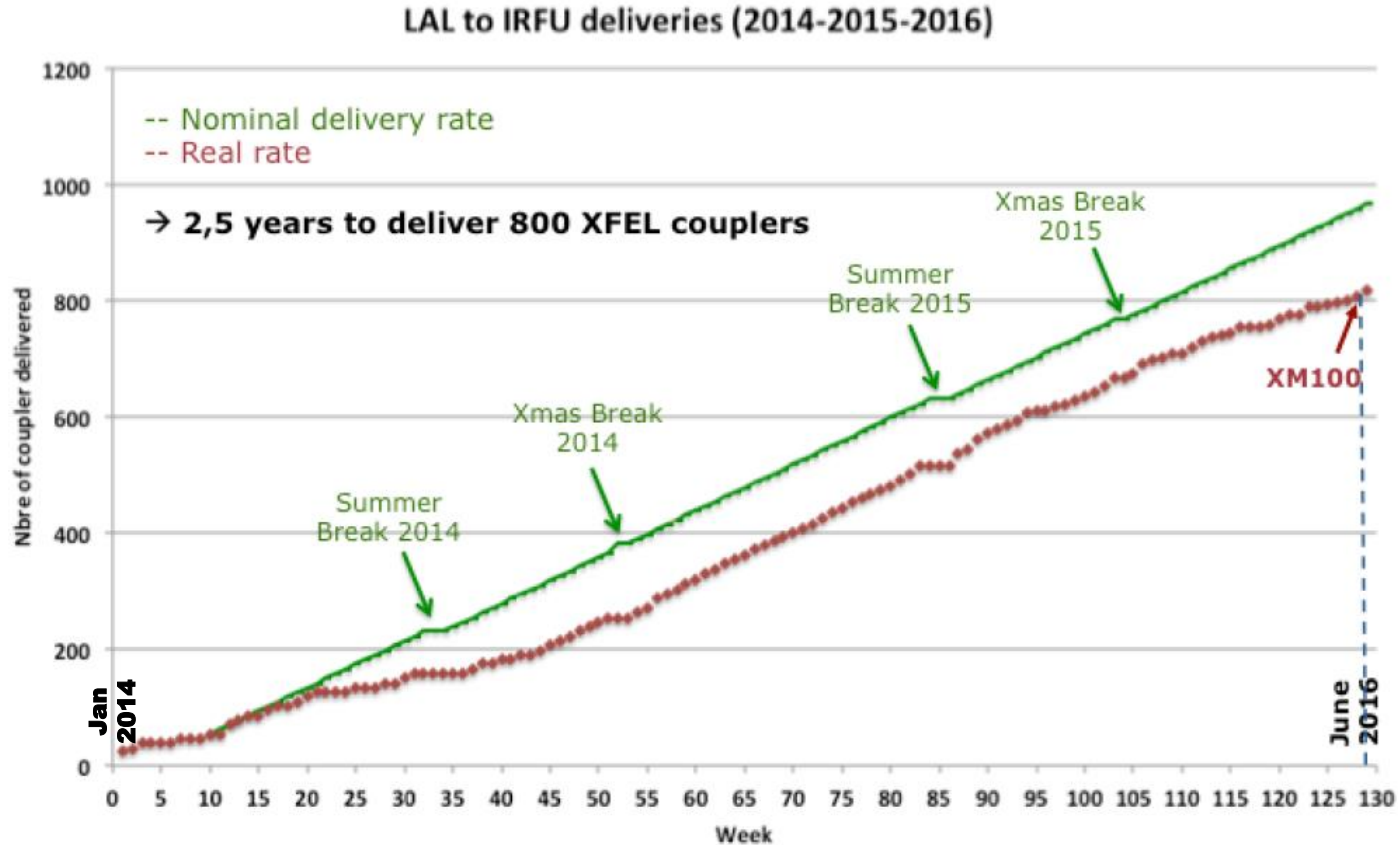
RI activity

- TiN coating on ceramics
- E-beam welding of ceramics (cold/warm windows)
- Assembly in clean room with WG transition, leak and actuator tests

Technical issues experienced at the early stage of the pre-Series phase

- RRR degradation due to post-brazing operation of copper coated parts
- ① April 2011: technical meeting with all stakeholders to discuss recovery actions
- ② Complete change of manufacturing sequences to braze parts before coating
Development of adapted copper coating processes on sub-assemblies (rather than parts)
- ③ Actual re-start of mass production / ^{OPEN} Contract final ending : 03/2016

Series manufacturing tender | The achieved delivery plan



Courtesy W. Kadbi – LAL Orsay (WWFPC 2016)

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Was industrialization in line with original expectations ?

- More than 670 EU-XFEL couplers manufactured by THALES/RI consortium ✓
- Pretty good reproducibility over quantities
- Globally, QA and performances respected
- Technology and skills acquisition (eg. copper coating on complex sub-assemblies)
- R&D progress and know-how for all stakeholders

- Limited design modifications / new manufacturing processes accepted for Series production ✗
- Final unit price not as low as expected
- Only one bidder involved in industrialization process did actually participate to Series manufacturing
- Financial and planning variances for all Parties

Recommendations / proposal

- Truly involve industry at the early stage of couplers development to ensure “Design to cost” approach
- Connect when possible prototyping / industrialization phases to Series to mitigate technological and financial risks for all Parties
- Implement new technologies & designs (3D printing, TiOx / TiN free ceramics , single window...)



“Il semble que la perfection soit atteinte non quand il n’y a plus rien à ajouter mais quand il n’y a plus rien à retrancher”

“It seems that perfection is achieved not when nothing is to be added but when there is nothing to subtract”

Antoine de Saint-Exupéry (*Terre des hommes* – 1938)

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