

# Attachment 1

## External Experts Areas of Expertise

### 1 - Complex civil constructions, nuclear buildings

- Secondary work
- Finishing
- Heating Ventilation and Air Conditioning
- Fluids
- Nuclear ventilation
- Cranes and handling device
- Architect
- Painting
- Commissioning
- Metal work
- Construction contract adjudication
- Construction claim assessment (schedule and cost)
- International construction contract administration (FIDIC, NEC, cost reimbursable, etc.)
- Work measurement

### 2 - High and medium voltage technology

- Power supplies
- Power electronics
- Power conversion
- High Voltage
- Electromagnetic compatibility
- Earthing/Grounding

### 3 - Project and Programme Management

- Planning and scheduling (Primavera, resource loading, baseline)
- Earned Value Management
- Risk Management (facilitation of identification or handling strategies workshops, schedule Montecarlo simulations)
- Cost Assessment (cost escalation, indexation, cost baseline, basis of estimate)
- Agile project management methodologies
- Contract and Performance Management
- Project Change Management
- Configuration Management
- Supplier management
- Engineering/production processes
- Complex manufacturing contracts
- PDM/PLM systems
- Work Breakdown Structure (WBS)
- Product Breakdown Structure (PBS)
- Systems engineering (INCOSE)

- Requirements management (DOORS)
- Interfaces Management

#### **4 – Human Resources Management**

- Job classification
- Staff Performance management
- Competency frameworks
- E-learning
- Talent management

#### **5 – Documentation and Business Process Management**

- Business Process Management (BPM)
- Documentation management (DMS)
- Improvement and organisational change management
- Lean Six-Sigma

#### **6 – Quality**

- Quality Assurance
- Quality Control

#### **7 - EU or International regimes/regulation for the control of exports, transfer, brokering and transit of dual-use goods and technology.**

- Compliance with the European Union Dual-Use Items Control Regime
- Dual Use items/technologies classifications
- International Export Control Regimes

#### **7bis – Specific Regulatory Matters**

- European Directives
- European Pressure Equipment Directive (including nuclear )
- French ESP/ESPN Regulation
- CE marking directives
- ATEX
- PED
- F-Gas
- EMC

#### **8 – Transportation of nuclear and conventional large components**

- Nuclear transportation regulation
- Incoterms
- Freight forwarding
- Logistics
- Technology
- Safety Analysis

#### **9 – Large components for conventional and nuclear installations**

- Pressure vessels for nuclear applications
- Regulations
- Complex welded structures
- Components subjected to high thermal loads

#### **10 - Remote Handling systems for nuclear environment**

- Mechanics,
- Rad-hard components
- Electronics,
- Control system
- Virtual reality
- Augmented reality

#### **11 - Nuclear fusion components design**

- Breeding blanket
- First Wall
- Divertor

#### **12 - Plasma and First Wall diagnostics**

- Optical
- Imaging
- Spectroscopic
- Microwave
- Neutrons and gamma rays
- Magnetic field
- Particle and pressure
- Physics
- Engineering
- Modelling
- Design
- Integration

#### **13 - Tokamak machine diagnostics**

- Optical systems
- Metrology
- Machine vision
- Image processing

#### **14 – Tokamak Heating & current drive systems**

- RF technologies,
- NB Systems
- Vacuum tubes
- Gyrotrons

#### **15 - Tritium technology**

- Water detritiation system

- Isotope separation system
- Tritiated produce processing, storage and handling

#### **16 – Cryogenic technology**

- Cryolines
- Helium technology
- Cryogenic materials
- Structural materials at cryogenic temperatures

#### **17 - Vacuum & Leak Detection Technologies**

- Components
- High level vacuum component
- Baking and outgassing procedures
- (hot) leak tests
- Surface cleaning and conditioning
- High vacuum in scientific projects
- Leak Detection

#### **18 - Chemistry and Technology of liquid metals and ceramics**

- Lithium technologies
- Liquid Metal Technologies
- Liquid Metal chemistry & corrosion
- Lithium ceramics

#### **19 - I&C and CODAC**

- Information engineering
- Electronic engineering
- Instrumentation engineering
- Fusion instrumentation
- System Engineering
- Fusion CODAS
- Large Experiments CODAS
- Investment Protection System
- Plant Safety Systems
- Nuclear Systems
- Fusion Plant Control
- Fusion Diagnostic System
- ATCA
- Compact PCI
- PCI express
- Real-Time Systems
- Distributed Real-Time
- Data acquisition
- Industrial SCADA
- Industrial Networks and FieldBuses
- EPICS

- Cable & Conduits
- Cubicles Design
- EMC expertise
- Electronic Design
- FPGA design
- Radiation tolerant electronics
- Robotic I&C
- Virtual Reality
- RF systems
- Microwave Systems
- HVAC Systems
- Fire detection Systems
- Power Distribution Instrumentation
- Power Supplies Instrumentation
- Surveillance Systems

## **20 - CAD-related technologies (CAD, Project Lifecycle Management)**

- CATIA
- CATIA V5
- Enovia SmarTeam
- Enovia v5
- Virtual Lab. Motion CATIA [Kinematics]
- DMU Kinematics (CATIA)
- CATIA assembly module
- DELMIA
- AutoCAD
- CAD/CAM integration in PLM

## **21 - Water cooling, chemistry & corrosion technologies**

- Water cooling
- Erosion of coolant water interfaces
- Radiolysis effects
- Crevice corrosion
- Stress Corrosion Cracking (SCC)
- In-situ monitoring and assembly of monitoring facilities (electrochemical potential, impurity accumulation, water sampling and test specimen assemblies using autoclaves)
- Qualification and assessment of metals and alloys used for coolant water interfaces

## **22 - Engineering & Design**

- Nuclear systems design
- Mechanical Engineering
- Mechanical Design
- Electrical Engineering
- Civil Engineering

- System design and modelling
- Hydraulics
- Cooling systems engineering
- Nuclear engineering
- Geotechnical engineering
- SF6 gas handling: large SF6 gas handling system design (>1 ton)
- RAMI Analysis expertise - Dependability analysis

### **23 - Analysis and modelling**

- Mechanical Analysis
- Civil engineering
- Earthquake, geotechnical and structural engineering
- Floor response spectra
- Soil structure interaction
- Structural Dynamics
- Analysis of reinforced concrete structure
- Analysis of fibre composite structures
- Experimental methods in structural mechanics
- Large-scale testing
- Blast and impact analysis
- Electromagnetic analysis
- Fluid dynamic,
- Computational Fluid Dynamics (CFD)
- Fatigue analysis
- Thermal mechanical analysis
- Nuclear analysis
- Neutronics analysis
- Nuclear Physics
- Superconductivity
- elasto-plastic analysis
- magnetohydrodynamics
- System identification and modelling
- Plasma modelling for engineering application
- Thermal fatigue
- High heat flux thermal fatigue
- Failure Mode Effects Analysis
- ANSYS
- ABAQUS
- MCPN

### **24 - Design codes and standards,**

- Industrial codes and standards
- Nuclear codes and standards

- RCC-MR
- RCC-MRx
- RCC-E
- RCC-M
- ASME
- ISO/IEC/IEEE/ASTM

## **25 – Nuclear Safety, Licensing and Protection of nuclear installations and devices**

- Radiation Protection technics
- Radiation Protection regulation
- Radiation shielding
- Nuclear hazards
- HAZOP
- OSHA
- Decommissioning
- Radwaste management
- Radwaste disposal
- Beryllium waste management
- Radiological monitoring
- Environmental monitoring
- Probabilistic safety analysis
- Deterministic safety analysis
- Best estimate safety analysis
- Conservative safety analysis
- Transient analyses
- Accident sequences analysis
- Advanced computer simulation for accident analyses
- Safety Follow-Up on Nuclear Procurements
- Nuclear facility licensing (Technical expertise)
- Beryllium handling & safety
- Airborne radioactive contamination confinement
- Radiation Shielding Calculations
- Dose Release Calculations
- French Nuclear Safety Regulations (support to analysis, inspection, training, etc.)

## **26 - Conventional (non-nuclear) Health and safety**

- French Health & Safety legislation
- Italian Health & Safety legislation (DL 81/2008)
- German Health & Safety legislation
- Hydrogen handling: ATEX application to H2 handling
- Hydrogen handling: risk assessment techniques
- Non-nuclear hazards

## **27 - Materials testing (destructive, non-destructive)**

- Destructive tests

- Non-destructive tests
- Post irradiation tests
- Definition of UT examination procedures
- UT level 3 (certificated) for 60 mm Stainless Steel
- Analysis of UT results in relation with codes and standards
- RX examination procedures and interpretation of defects on 60 mm Stainless Steel
- Digital radiography
- Material testing at cryogenic temperatures

## **28 -Mechanical fabrication and Joining techniques**

- Technologies of fabrication
- Standard manufacturing and joining processes (and simulation)
- Boiler production with thick (60mm) Stainless Steel
- Large Bellows design (>1m diameter)
- Bellows for nuclear application
- High precision machining
- Machining of large scale components
- Laser Sintering
- Electron Beam Sintering
- Additive manufacturing technologies
- Welding techniques
- EB welding
- TIG welding
- laser welding
- Arc welding processes
- Friction welding processes
- Brazing processes
- Hot Isostatic Pressing (HIP)
- Powder HIP
- HIP of heterogeneous materials
- Diffusion bonding
- EB and TIG welding shrinkage analysis on thick (60mm) Stainless Steel
- EB and TIG welding process qualification (WPS, WPQR) on Stainless Steel
- Explosion bonding
- WPS
- fitting of pieces
- field interaction knowledge
- Brazing (Metallic, Bi-metallic structures and Non-metallic to metallic structures)
- Heat treatment
- Surface treatment (metallic components)
- CNC machining
- Computer aided manufacturing (CAM)
- CMM (coordinate measuring machine)
- Beryllium manufacturing (fabrication, machining, handling and safety)
- Codes and standards related to joining and non-destructive testing

## **29 – Assembly, Installation, Validation and testing**

- Assembly of complex and large equipment
- Manipulator aided assembly
- Assembly of high vacuum components
- Assembly of optical components
- Acceptance tests
- Vacuum testing
- Pressure testing (including hydraulic and thermo-hydraulic)
- EB test facilities operation and commissioning
- Simulation analysis and product assembly studies
- Assembly/ Installation Documentation Management (SmartPlant)

### **30 - METROLOGY**

- Geometrical survey
- Tolerance analysis
- Spatial Analyser
- Polyworks
- Metrology simulation
- Metrology plans
- Reverse Engineering
- Virtual Assembly

### **31 - Plasma Engineering**

- Plasma engineering (component design verification, engineering of scenarios, plant integration)
- Plasma-Wall interaction (normal, transient and off-normal events)
- Plasma Operations (Tokamak operation, Operational limits, plasma commissioning)
- Plasma Scenario simulation (1D, 2D simulations, integrated modelling)
- Plasma modelling (transport, MHD, plasma edge physics, fast ion physics, run-aways, etc)
- Heating and Current drive physics and modelling (including NTMs)
- Plasma fuelling and pumping
- Disruptions

### **32 - Tokamak mm-waves launchers**

- mm-wave engineering
- mm-wave component design and testing
- mm-wave special components (such as windows, tapers, waveguides, etc.)
- mm-wave transmission (guided and quasi-optical)
- electro-magnetic aspects of mm-wave transmission (HE<sub>mn</sub>, TEM<sub>00</sub>, specific modelling)
- mm-wave specific diagnostics (ECE, IR, component-specific diagnostics for ITER)

### **33 – Tokamak Ion Cyclotron Heating (ICH) antenna**

- ICH engineering
- Electrical engineering for high power ICH antennas
- Brazing of metallic/non-metallic materials
- ICH wave transmission

- ICH special components
- ICH antenna control and protection
- ICH specific diagnostics (arc detection, reflectometry, component-specific diagnostics for ITER)
- ICH operation with fusion plasmas
- ICH physics
- Mechanical analysis
- Seismic analysis

### **34 - TOKAMAK and PLASMA Control System Engineering**

- Tokamak plasma control (experience in design and/or operation of plasma control systems in a tokamak)
- Additional Heating Control (Experience in design and/or operation of additional heating system in a fusion device, including Neutral beams, Ion Cyclotron, Election Cyclotron and Lower Hybrid system)
- Tokamak control, operation and protection (Experience in design and/or operation of systems for the management of safe and efficient tokamak operation)

### **35 – Superconductivity and Superconductor Magnets**

- Superconducting material
- Superconductor Magnet design and technology
- Superconductor cable and conductors production
- Superconductor cable and conductors test
- Magnet design
- Manufacturing of Superconducting coils (winding / impregnation)
- Testing of Superconducting coils (warm and cold testing)
- Cryogenics design and technology applied to magnet cooling and stabilization

### **36 - Information Communication Technologies**

- SQL, PL/SQL Programming, stored procedures, functions, triggers and database development
- Oracle databases: Programming, stored procedures, functions, triggers and database development
- Automation of manual processes
- SQL performance and Tuning
- ETL processes
- Database documentation management (development)
- SharePoint data bases
- Continuous integration, continuous delivery

### **37 – Measurement Systems**

- Requirements specification
- Engineering
- Design
- Manufacture
- Sensors

### **38 - Industrial Intelligence**

- Financial assessment and evaluation of companies
- Commodity markets
- International (non-European) industrial markets
- International (non-European) financial markets
- Economic and impact analysis of large projects
- Market survey methods
- Financial planning and analysis
- Budgeting and forecasting
- Probabilistic forecasting

### **39 - Accelerator related technology:**

- High power, high intensity linear accelerators engineering
- CW high intensity ion sources (ECR sources)
- RF cavities development (RFQ, superconducting cavities)
- RF systems
- High power beam transport lines
- Beam diagnostics
- Beam Dynamics
- Control system
- Machine protection system
- Radioprotection system
- Accelerator commissioning

### **40 - Insurance Services**

- Decennial insurance
- Third party liability insurance
- Nuclear insurance
- Construction insurance
- Others

### **41 – Communication**

- Science Communication
- External Communication strategy
- Stakeholder engagement and communication
- Internal Communication
- Social media strategy and application
- Website analysis and development