



Contribution ID: 39

Type: **not specified**

Reliability Gets Hot at 100 Million Degrees: RAMI Challenges and Opportunities in Fusion Energy

Thursday, 28 May 2026 16:20 (25 minutes)

Fusion energy is rapidly transitioning from experimental research to a highly capitalized industrial ambition, with private and public actors targeting near-term deployment of fusion power plants. The cumulative funding in private fusion surged to 13 billion EUR since 2020. The fusion private ecosystem is now larger than ever, with 77 companies and growing. However, beyond the well-known physics and engineering challenges, a critical gap remains largely unaddressed: the absence of robust Reliability, Availability, Maintainability, and Inspectability (RAMI) frameworks to support credible lifetime and performance assessments.

Today, there is limited comprehensive methodology to justify key parameters such as plant availability or maintenance strategies in fusion environments. This lack of validated systematic and well-founded approach directly impacts the ability to estimate Levelized Cost of Energy (LCOE), undermining confidence in economic viability and scalability. In many cases, RAMI considerations are still secondary to performance driven design, creating a significant risk for future deployment and operation of an expected series of thousands of plants to be operated.

At the same time, this gap represents a major opportunity. As fusion projects move toward industrialization, the demand for structured RAMI methodologies, predictive tools, and data-driven models will grow rapidly (including, of course, Artificial Intelligence tools). Organizations capable of delivering credible and standardized lifetime assessments, availability projections, and maintenance strategies will play a key role in enabling investment decisions and de-risking fusion projects. RAMI is poised to become a cornerstone discipline in the transition from experimental devices to reliable fusion power plants.

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Session Classification: Special Session: Maintenance in the Fusion Industry