

**Advanced Quantification of Uncertainties In Fusion modelling at the
Exascale with model order Reduction (AQUIFER)
1 December 2021 – 14 March 2024
T/AW085/21**

**Report [Milestone 3]
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Note that many activities are joint with the EPSRC SEAVEA project due to synergies and cost efficiencies (e.g. PI time, events, HPC access to ARCHER2 in SEAVEA) as mentioned in the AQUIFER project description.

A PhD student will start in April (Rob Akers and James Buchanan from UKAEA participated in the section panel on 4 February 2022) and a permanent research data scientist is in the process of being recruited (45% FTE total over 27.5 months on AQUIFER, and in the new UCL Centre for Advanced Research Computing (ARC)) with interviews taking place on 11 March 2022.

Our project was affected by Covid-19 due to the PI and others getting ill within the funding period.

Activity No 1

Objective 1: To explain and disseminate the findings

Meetings with UKAEA have taken place in three formats:

- NEPTUNE Progress Meetings
- SEAVEA Fusion Use Case Meeting 3 March 2022: this allowed for instance steps for the choice of Nektar++ and the use of observations.
- 10 March 2022: Meeting with the control, Data Assimilation and Digital Twinning group (Roger Powell, Tom Deighan, Mihai Hrecinuc)

Objective 2: To assist the NEPTUNE community with the implementation of UQ

- James Buchanan and Ander Gray are now added to SEAVEA WP1 Meetings (fortnightly)
- Roger Powell, Tom Deighan, Mihai Hrecinuc will iterate with the RADDISH and AQUIFER group on Julia-based Data Assimilation (Particle Filter and Kalman filtering).

Activity No 2 (Start: 1 April 2022)

Objective 1: To provide surrogates models tailored to the need of the NEPTUNE community

Preliminary steps include integration of Turing MOGP and SEAVEA toolkits.

Objective 2: To calibrate fusion modelling against past observations

Preliminary steps have taken place. The best steps are to calibrate NEKTAR++ convection against observations. These observations will become available through an imaging system from the University of Leeds within a couple of months. NEKTAR++ is now run in 2D first on ARCHER2, then in 3D to adapt methods to that scale.

Objective 3: To assimilate real-time observations into fusion modelling

Roger Powell, Tom Deighan, Mihai Hrecinuc will iterate with the RADDISH and AQUIFER group on Julia-based Data Assimilation (Particle Filter and Kalman filtering). We will benefit from the facility CHIMERA in Yorkshire to get real-time data.

Activity No 3

Objective 1: implementation of the advanced surrogate modelling and DA methods in activity 2 within SEAVEA

This will follow activity 2. Initial releases of the SEAVEA toolkit featuring advanced surrogate modelling (e.g. active subspace) are in progress.

Objective 2: Coupling between SEAVEA and fully-resolved models using MUSCLE3

In progress.

Objective 3: Integration of DA and UQ platforms

This will follow activity 2. Not started.

Activity No 4

Objective 1: Deployment of the UQ software platform on ARCHER2 for use by individual teams in NEPTUNE

In progress, with ARCHER2 now being utilised for Nektar++ 2D runs and UQ by Kevin Bronik.

Objective 2: Deployment of the DA software platform on ARCHER2 for use by individual teams in NEPTUNE

Not started.

Objective 3: Deployment of the UQ and DA software platforms on ARCHER2 for use for the integrated fusion model by all teams in NEPTUNE

Not started