DELIVERABLE 1.4

Technical information about possible future joint missions

COST Action:	**CA15220**
Project acronym:	**QTSpace**
Project title:	**Quantum Technologies in Space**
Funding scheme:	**COST Association**
Start date of project:	**20 October 2016**
End date of project:	**19 April 2021**
Due date of the Deliverable:	**October 2020**
Deliverable issued:	**March 2021 (extension granted)**
Dissemination Level:	**Public**
Version:	**1.0**

TABLE OF CONTENT

INTRODUCTION

This document looks at a selection of eight space mission proposals which aim at exploiting the unique conditions of space and satellite platforms to perform fundamental physics. We construct a compatibility matrix that helps to judge which pairs of missions can be combined.

IMPLEMENTATION

Our goal is to exploit information such as that tabulated in Deliverable D1.3 to identify which pairs of proposed experiments are best suited to being combined on the same platform.

The key experiments and studies were selected during QTSpace working group meetings, which took place during the course of the Action. During these meetings, the status of the state-of-art and foreseen improvements of possible proof-of-principle experiments, implementations and applications was assessed. The selection here presented is the result of the discussions and confrontation which was pushed forward by the QTSpace community, and it is also based on the indications from the scientific and industrial community.

Atomic systems

STE-QUEST [1] (Space-Time Explorer and Quantum Equivalence Principle Space Test) is a proposal for an ESA mission for atomic interferometer with atomic clocks for testing the validity of the Einstein Equivalence Principle.

AEDGE [2] (Atomic Experiment for Dark Matter and Gravity Exploration) is a proposal for a mission for probing dark matter and gravitational-wave measurements through the use of atom interferometry.

SAGE [3] (Space Atomic Gravity Explorer) is a proposal for a multipurpose mission employing atom interferometry for observing gravitational waves, dark matter, possible violations of Einstein Equivalence Principle and Bell inequalities.

Massive objects

MAQRO [4] (MAcroscopic Quantum ResOnators) is the only proposal, to the best of our knowledge, which aims to explore decoherence mechanisms and the boundary between quantum and classical worlds with interferometric techniques of massive objects.

Photonic systems

Space QUEST [5] (Space—Quantum Entanglement Space Test) is a proposal for quantum communication between ISS and ground, which will study decoherence in an entangled photonic system.

CQuCoM [6] (CubeSat Quantum Communications Mission) is a proposal for quantum communication between CubeSats and ground, which will study decoherence in an entangled photonic system.

QEYSSat [7] (Quantum Encryption and Science Satellite) aims to test quantum key distribution and quantum entanglement sciences using a quantum receiver in space.

Nanobob [8] is a proposal for quantum communication between CubeSats and ground in an uplink configuration. It will study decoherence in an entangled photonic system.

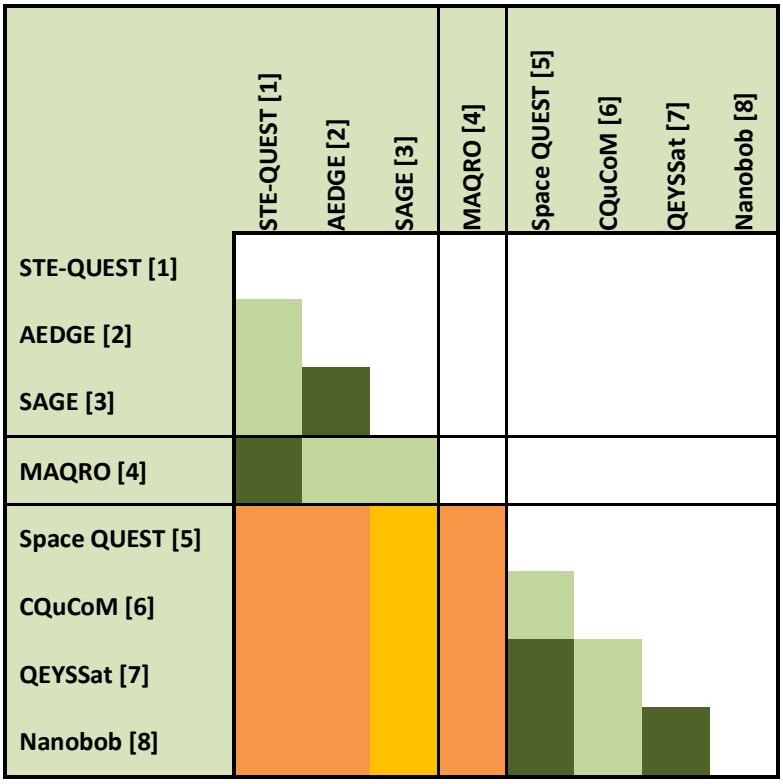

Table 1. Mission compatibility for several pairs of proposed experiments. The compatibility matrix uses a four-colour rating, with orange (■) denoting the least compatible pairs, gold (■) slightly better compatibility, light green (■) reasonable compatibility, and dark green (■) for the most compatible pairs. The matrix is divided into atomic, massive, and photonic systems.

The results of our analysis are summarised in
Table ***1***. To construct this matrix, we took into account the following facts:

- STE-QUEST, AEDGE, SAGE, and MAQRO all require extremely stable and drag-free platforms.
- SAGE will have ground-to-satellite links whose optics and subsystems could be used to enable QKD and quantum communication channels.
- The quantum communication experiments are neutral with respect to the requirements of the other experiments.

CONCLUSIONS

Broadly speaking, the quantum communication experiments are mostly compatible with each other, since CQuCoM, QEYSSat, and Nanobob all have nearly identical goals. Nevertheless, there are key differences in the precise configuration of each proposal; for example, CQuCoM operates in downlink configuration, whereas SPACE-QUEST, QEYSSat, and Nanobob all operate in uplink configuration.

REFERENCES

[1] B Altschul, *et al.*, Adv. Space Res. **55**, 501 (2015).
[2] Y A El-Neaj, *et al.*, EPJ Quant. Tech. **7**, 6 (2020).
[3] G M Tino, *et al.*, EPJ D **73**, 228 (2019).
[4] R Kaltenbaeck, *et al.*, MAQRO M4 Mission Proposal (2017).
[5] S Kodoru Joshi, *et al.*, New J Phys. **20**, 063016 (2018).
[6] D K L Oi, *et al.*, EPJ Quant. Tech. **4**, 6 (2017).
[7] T Jennewein, *et al.*, Proc. SPIE **8997**, 89970A (2014).
[8] E Kerstel, *et al.*, EPJ Quant. Tech. **5**, 6 (2018).