Findings:

- The ALICE upgrade program is aiming at increasing the statistics for key measurements by a factor of 100 over the numbers achievable with the present detector. This requires all key subsystems being able to cope with a 50 kHz interaction rate in Pb-Pb and a 200 kHz rate in pp and p-Pb collisions. Each collision is to be shipped to the online systems, either upon a trigger or in a self-triggered, continuous fashion. This requires the upgrade of the read-out systems of most detectors as well as a system-wide upgrade of trigger and DAQ.

- Although the ALICE Read-out and Trigger System Upgrade TDR details upgrades to 12 subsystems this review focuses only on the most critical systems: the ALICE Muon Chambers (MCH), the Muon Identifier Detector (MID), the Fast Interaction Trigger (FIT) upgrade. Not included in this TDR are upgrades to readout systems of detectors that are subject to a major upgrade by themselves and are thus covered in a separate TDR (ITS, TPC, and MFT). However, the development and testing of key electronic components for these upgrades are part of this TDR.

- The project is centered around two key projects: the SAMPA chip and the CRU. The SAMPA is the front-end ASIC used to upgrade TPC and MCH detectors, the CRU is core part of the read-out upgrade and will be used by TPC, MCH, ITS, MID, MFT, ZDC, and TRD.

- The SAMPA ASIC is the successor of the sALTRO chip. The development and production is organized as an independent project. Testing the chip is part of the MCH and TPC upgrade project. A total of 83k (incl. 15% spares) chips will be needed in ALICE of which 33k are required for the MCH upgrade. All chips are scheduled to be produced by mid 2016.

- The CRU is the central part of the ALICE read-out and control system. It is developed in collaboration with LHCb. The CRUs will be placed in the counting room and connected via fiber channels to the detectors in the cavern. The project is not independently funded but relies on funding of the referring user projects.

- Key items common to all upgrades will be supplied to the various subsystem groups, early with either prototypes or emulators, later with pre-series parts in order to allow for early testing and commissioning before the final production versions will be provided.

- Upgrades described in this TDR are coordinated by the ALICE System Upgrade Manager; he also oversees directly all common projects such as CRU, SAMPA, and the Central Trigger Processor (CTP) project. The ALICE sub-detectors upgrade projects are supervised by the respective upgrade managers who report to the System Upgrade Manager.

- The cost of the SAMPA ASIC development, testing, and the production of the required 83k chips is 1.712 MCHF, that of the CRUs including those for TPC is 3.339 MCHF. Upgrade of MCH amounts to 1.714 MCHF (excluding the cost for SAMPA included above), that of the MID to 0.746 MCHF. The cost of the FIT design and construction is 1.672 MCHF.

Comments:

- The UCG is impressed by the answers the ALICE collaboration has provided to the questions and the quality of the written documents, which included all the needed information. Project costs, manpower need, and risk factors were estimated in sufficient detail.

- The ALICE Readout and Trigger Upgrade is a very challenging project with an aggressive time schedule. Production of components, testing, and assembly will require a substantial amount of expertise and proficient project management.

- Some concerns by the UCG are related to the management organization of ALICE read-out upgrades. While the system upgrade manager has considerable authority, his influence on the individual sub-detector projects is limited and has to proceed through the liaison with the
spokesperson and/or ALICE management. This might affect the quick response to shortfalls and critical issues that might arise. The UCG made ALICE aware of their concerns.

- The overall risk to the ALICE program lies with the common components such as CRU and SAMPA. Delays or technical problems will affect multiple systems.
- One of the main risk factor is the possible noise behavior of the analog front-end in the SAMPA ASIC. Solutions to amend these issues exist but will affect the time schedule. In order to compensate for design and/or production problems additional time has been planned into the schedule to ensure the delivery schedule to the subsystems.

**Recommendations:**

- The cost and manpower estimate is found to be reasonable and should be approved.
- A project of this complexity requires a manager who has the mandate to make difficult choices and decisions when necessary. Therefore, ALICE should ensure that the system manager has sufficient authority to be able to oversee all of the proposed upgrades including those of the subsystems.
- Given the complexity of the project’s management structure, the milestones become the best indicators of progress, or problems. Therefore, the Scrutiny Group should carefully monitor the milestones, and ALICE should promptly submit a mitigation/impact strategy should a milestone be missed.