	ALMA CHANGE REQUEST	CRE #: ALMA-XX.xx.XX.xx-0016-A-CRE
	TITLE: A Significant Upgrade of the ALMA Correlator	

Description of change (detailed description of change proposed) and Justification:

The requested change is to upgrade the 64-Antenna Correlator. After the upgrade, it would process twice the current bandwidth, the entire output of the 4 to 12 GHz IF system, and produce 8 times the current number of spectral points and enhance the time resolution of the current correlator from 16 msec for cross-correlations to 1 msec. A detailed description of the proposed change is contained in the project proposal, “**A Significant Upgrade to the ALMA 64-Antenna Correlator**”. This document is included in this Change Request zip archive.

Our intention is to execute the upgrade in two phases. The first phase would increase the resolution while the second would increase the bandwidth. The rationale behind this is that the impacts for phase 2 are not yet fully scoped.


Justification: This upgrade is part of the ALMA 2030 vision. It would provide a scientifically significant increase in observing efficiency. It would also provide additional spectral resolution, useful for Bands 1 and 2. The enhanced time resolution may be useful for observations of transients, but would possibly require more bandwidth to the archive than will be available. “Spigot” ports will be available for the higher time resolution data should a future upgrade want to tie into these ports to bypass the limitations of the archive. A complete science case is made for the upgrade in the above-mentioned proposal.

Additional information in attached documents:

These are referenced in-line in the other sections of this CRE.

Impact: ☒ Specifications ☒ Science ☒ Cost ☒ Schedule ☒ Safety ☒ Technical ☒ Other (specify): Commissioning

Date Submitted: 2016-02-12	Date Decision Required: As soon as possible
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Description of impact:

Many systems would be impacted. In some cases, the impact is a complete design and replacement while in others it only involves changing a few lines of code. These are summarized in the document “**A Significant Upgrade to the ALMA 64-Antenna Correlator: Project Recommendation**” which will be provided in the near future. More detailed analyses of impacts are included in additional attached documents generated during the Correlator Upgrade Study: “**Recommended Software System Changes**”, “**Recommended ALMA Hardware Changes Required by the Correlator Upgrade**”.

Specifically addressing each of the impact check boxes:

Specifications:

- ALMA System Specification #530: Spectral resolution, minimum for the 64-Ant Correlator: < 1KHz (single polarization only)
- ALMA System Specification #541.1: This specification improves to 1 msec integrations and readout interval all baselines. (As is currently the case the availability of this mode is limited by the CDP and archive data rate.)
- ALMA System Specification #541.2: This specification does not change and is in fact a subset of 541.1.
- ALMA System Specification #542: Per the explanatory note on p. 115 of the current ALMA spec, this requirement is the data rate to the CDP computers from the correlator hardware. These data links will use current, standard technology to replace the semi-custom HPDI. There will be 16 10 Gbps optical links to the CDPs. We plan to transmit approximately 5 Gbps on each link, limited by the CDPs ability to process the data. This corresponds to 80 Gbps total or 2.5 G 32-bit results per second. As is the case for the current system, real, not complex, correlations are sent to the CDP. Therefore the spec should probably read 2.5 G real correlations per second.

Science:

- See the science case in the attached proposal. A more recent version of the science case is included in the Change Request zip archive. It separates the benefits of the resolution and bandwidth phases.

Cost:

- For the detailed costing of the correlator upgrade, see the attached correlator upgrade proposal
- An estimated of the cost for upgrading all systems impacted by the correlator upgrade will be provided soon. Due to the limited time available to provide this, it will be only a ROM.

Schedule:

- Our current plan is to install the correlator upgrade during the February shutdown of 2022. This would include all LRUs for both phase 1 and phase 2 of the correlator upgrade project. In the best case scenario, all other impacted systems could also be upgraded at this time so that phase 1 and phase 2 of the correlator upgrade would end concurrently. (Phase 1 is the resolution upgrade; phase 2 is the bandwidth upgrade.) This would be followed by a commissioning session which we estimate would take 2 to 3 months. Another scenario is that the phase 2 bandwidth upgrade would be timed such that all impacted systems would be ready for installation. This would take place during some February later than 2022. In this case, two commissioning sessions, each approximately 2 to 3 months in duration would be required.

Safety:

- See the safety plan included in the Change Request zip archive.


Technical:

- See the System Modification Overview appended to the correlator upgraded proposal included in this Change Request zip archive.

Commissioning:

- The correlator group does not have the expertise to commission the upgraded correlator. It will perform self-tests of the upgraded correlator to assure that it works correlator in isolation. It will provide technical support for commissioning. The ALMA scientists, working together with scientists at the ARCs, are the best group to perform the commissioning task. The ALMA Phasing System is a special case: we intend to work directly with the designers of this system in verifying that this system is still functional after the upgrade. A Commissioning, Science, and Verification (CSV) plan will be developed in collaboration with the JAO when the project commences. The duration of this task is addressed in the above “schedule” bullet.

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Affected products to be modified: 64-Antenna Correlator.
Affected documents to be revised: Many documents in the current correlator CIDL, CORL-60.00.00.00-068-E-LIS , will need to be revised. Those that will <i>not</i> change include those having to do with the infrastructure (the ICD with the building, seismic design package, mechanical drawing package), those having to do with System Control and Monitoring (memory maps, bootstrap, documents relating to the LTA, QCC and SCC control cards, motherboards)
Summary of Technical Impact (state concerns and/or merit): This upgrade provides a significant step towards the observatory's ALMA 2030 vision. The bandwidth of the correlator is doubled. Its resolution is increased by a factor of 8. Its time resolution for cross-correlation products is increased by a factor of 16. It will also provide a major component for a test facility at the OSF, which will have significant positive impacts for installation, test, commissioning and operations (see Stuart Corder's Fifth Quadrant Proposal, not included in this archive and our upgrade proposal included in this archive for additional detail).
Summary of Schedule Impact: The upgrade will be installed during a February shutdown period and this will have no impact on the ALMA observing schedule. The subsequent commissioning will impact operations for 2 to 3 months.
Summary of Budget Impact: The correlator upgrade will be funded by NA ALMA Development.. (Funding for other impacted systems is not clear at this time.)
Remarks:

Name	Signature	Date	App	Rej	Name	Signature	Date	App	Rej
INITIATOR			<input type="checkbox"/>	<input type="checkbox"/>	NRAO OM			<input type="checkbox"/>	<input type="checkbox"/>
IET SE			<input type="checkbox"/>	<input type="checkbox"/>	ESO OM			<input type="checkbox"/>	<input type="checkbox"/>
IET LEAD			<input type="checkbox"/>	<input type="checkbox"/>	NAOJ OM			<input type="checkbox"/>	<input type="checkbox"/>
IET HEAD			<input type="checkbox"/>	<input type="checkbox"/>				<input type="checkbox"/>	<input type="checkbox"/>
			<input type="checkbox"/>	<input type="checkbox"/>	CCB SECRETARY			<input type="checkbox"/>	<input type="checkbox"/>
JAO SE			<input type="checkbox"/>	<input type="checkbox"/>	DEPUTY DIRECTOR			<input type="checkbox"/>	<input type="checkbox"/>

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