ALMA Phasing Project Hazard Analysis and Safety Compliance Plan

ALMA-05.11.10.01-0003-A-PLA

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Change Record

Revision	Date	Affected Paragraphs(s)	Reason/Initiation/Remarks
A.1	2013-05-09	All	Initial draft
A.2	2013-05-07		Added certification list and laser comments
A.3	2013-05-16		Clarified laser comments regarding ZR (Long range) transceivers
A	2013-06-13	Table 9 Certifications	Corrected GPS model and antenna, was incorrect model in A.03

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1.0 GENERAL

1.1. Purpose and Scope

This document provides a systematic examination of the ALMA Phasing Project system design that assesses potential risk of hazards within the system, may be present in its environment, or associated with its use. Additionally, this plan addresses steps APP shall take to meet Safety Compliance Requirements. It should be noted that APP equipment installs in existing environments where a hazard analysis has already been performed on the existing host rooms, racks, and infrastructure. This report does not retrace the content of those reports, but provides a subsidy to them for the equipment being added. See [RD03] and [RD04] for examples where these assessments have already been performed. In most cases, hazards that apply to the APP equipment are similar to existing equipment, safety protocols and labeling is already in place, and procedures already include mitigation against these safety risks.

Section 2 describes criteria used to rate the probability and severity of a potential hazard. Section 4.1 contains the Risk List which details the evaluation of all risk areas in relation to the ALMA Phasing Project. The Hazard Analysis in Section 4.2 provides a thorough evaluation of critical items identified in the Risk List.

1.2. Applicable Documents

This section contains a list of Applicable Documents, which define the content, requirements and specifications for this document and a list of Reference Documents, which contain information related to the products and processes in this document.

Table 1: Applicable Documents

Reference	Document Title	ALMA Doc. Number
[AD01]	ALMA Product Assurance Requirements	ALMA-80.11.00.00-001-D-GEN
[AD02]	ALMA Subsystem Testing and Handover Guidelines	ALMA-80.00.00.00-008-A-PLA
[AD03]	ALMA Safety Risk Analysis Procedures	ALMA-10.08.00.00-004-A-GEN
[AD04]	ALMA General Safety Design Specification	ALMA-10.08.00.00-003-B-SPE

1.3. Reference Documents

Table 2: Reference Documents

Reference	Document Title	ALMA Doc. Number
[RD01]	APP Project PlanV1.2b	
[RD02]	ICD Between ALMA Phasing Project and ALMA Site	ALMA-05.11.10.49-20.00.00.49-A-ICD
[RD03]	BEND Photonic Central LO Safety Hazard and Risk Analysis Report	BEND-50.01.00.00-082-A-REP
[RD04]	64-Antenna Correlator Hazard Analysis	ALMA-60.00.00.00-057-A-REP

1.4. Definitions

For the purpose of this document, the following terms and definitions apply:

Accident – An undesired event resulting in death, injury, damage to health, damage to property or other form of loss.

Harm - Physical injury or damage to property or to the environment.

Hazard - a biological, chemical or physical agent or condition with the potential to cause harm. Hazards can be qualified to define its origin or the nature of the expected "harm" (e.g., electric shock hazard, crushing hazard, cutting hazard, fire hazard).

Hazard Identification – Identification of biological, chemical, and physical agents capable of causing adverse health effects.

Hazard Verification – All activities performed to demonstrate that the design meets or is capable of meeting the specified safety requirements.

Life-cycle - All phases of the item's life including design, research, development, test and evaluation, production, deployment (inventory), operations and support, and disposal.

Risk – An expression of the likelihood of injury or harm resulting from a hazard. A combination of the probability of an adverse health effect and the severity of that effect.

Protective Measure - means used to reduce risk. Protective measures include risk reduction by inherently safe design, protective devices, personal protective equipment, information for use and installation, and training.

Safety - freedom from unacceptable risk

1.5. APP Provisions

- Review the design concept for safety issues and risk, identify hazards throughout the design and eliminate or reduce the probability or severity of harm.
- Complete the Preliminary Hazard Analysis.
- Design safety solutions and assess the design effectiveness

2.0 RISK ESTIMATION PROCESS

This section details the criteria used to evaluate the severity of potential hazards, the likelihood or probability of their occurrence and the type or category of exposure.

2.1. Hazard Severity Ratings

The following table details the severity levels used to rate the magnitude of consequence related to each identified risk, should it occur. These ratings are used to evaluate the risks in the Risk List and the Hazard Analysis.

Table 3: Hazard Severity Ratings

Category	Severity Description	Mishap Definition
1	Catastrophic	Death and/or the instrument is more than 4 weeks out of operation or it cannot be recovered at a reasonable cost.
2	Critical	Severe injury, severe occupational illness, and/or the instrument can be repaired, but support from the supplier/industry is necessary and/or the instrument is up to 4 weeks out of operation.
3	Marginal	Minor injury, minor occupational illness, and/or the instrument can be repaired by ALMA staff, and/or the

		instrument is up to one week out of operation.
4	Negligible	Less than minor injuries, less than minor occupational illness, and/or the instrument is less than one day out of operation.

2.2. Hazard Probability Levels

The probability that a hazard will occur during the total lifetime of an instrument is defined using the following criteria. The ratings are used in the Risk List and the Hazard Analysis.

Table 4: Hazard Probability Levels

Level	Probability Description	Definition
A	Frequent	Likely to occur more than once per year
B	Probable	Will occur 6 to 10 times during the whole lifetime
C	Occasional	Will occur 2 to 5 times during the total lifetime
D	Remote	Unlikely but possible to occur once during the total lifetime
E	Improbable	So unlikely that an occurrence can be assumed not to be experienced.

2.3. Risk Acceptance Criteria/Rejection Criteria

The following figure prioritizes hazards for use in defining corrective actions.

Table 5: Risk Acceptance Criteria

Frequency of Occurrence	Hazard Categories				Accept/Reject Criteria
	Catastrophic	Critical	Marginal	Negligible	
Frequent	1A	2A	3A	4A	Unacceptable
Probable	1B	2B	3B	4B	Undesirable, ESO & AUI/NRAO decision required.
Occasional	1C	2C	3C	4C	Acceptable with ESO & AUI/NRAO review.
Remote	1D	2D	3D	4D	Acceptable without ESO & AUI/NRAO review.
Improbable	1E	2E	3E	4E	Acceptable without ESO & AUI/NRAO review.

2.4. Hazard Exposure Categorization

The following list defines the categories of estimated exposure for a potential risk and the scope of effect should the risk occur. These categories are used to evaluate risks in the Risk List.

O - Occupational exposure, i.e. hazard has potential impact only for workers in immediate area.
F - Could impact workers in the facility but not likely to impact the outside environment.
E - Hazard that could have environmental consequences, e.g. a solvent spilled in large enough quantities to cause environmental pollution outside the facility.
P - Hazard that could have consequences to the off-site public.

3.0 SYSTEM DESCRIPTION

3.1. APP Sub-system Components

This section lists the components of the APP Sub-system and locations where they are installed.

- **Equipment installed in the Correlator room at the AOS**
  - PICA, custom PCB assembly, correlator racks
    - Mellanox MFM1T02A-SR optical transceiver
  - ATX Power Supply, 48V, COTS, correlator racks
  - GPS Reciever, COTS, communications rack
    - Symmetricon XLi
  - XW-100 Fiber Multiplexer Chassis, communications rack
    - Sumitomo SXP3100SX 10GB-SR (short range xcvr)
  - LVDS to Twinax adapter, custom, passive connector adapter, communications rack
  - 1PPS Distributor, custom Budbox with PCB assembly, communications rack

- **Equipment installed in the Local Oscillator room at the AOS**
  - H-Maser Rack
    - Hydrogen Maser, H-Maser Rack
    - Intelligent power strip, H-Maser Rack Eaton-Pulizzi TPC2365/MTD
    - Xytronix Research temperature sensor module, X-DAQ-2R1-4T-E, H-Maser Rack

- **Equipment installed on the roof of the AOS**
  - GPS Antenna
    - AeroAntenna Technology AT575-142 or equiv.

- **Equipment installed in the archive room at the OSF**
  - Mark 6 VLBI Recorders, racks 11 and 12
  - XW-100 Fiber Demultiplexer Chassis, rack 11 or 12
    - Sumitomo SXP3100SX 10GB-SR (short range xcvr)
    - Sumitomo SXP3102DA-Fxxx 10GB-ZR (long range xcvr)

3.2. List of Hazard Sources for the APP

This section itemizes general sources of hazards that will be reviewed and addressed, as they are applicable to the APP System and its operating environment.

3.2.1. Environmental

- Precipitation (rain, snow, hail,…)
- Lightning
  - Humidity
  - Temperature
  - Altitude (air pressure)
  - UV light
  - Wind
  - Earthquake
  - Acceleration / movement
  - Shock during transportation
  - Electric power fluctuation
  - Electric power interruption
- Electric shock
- Software
- Hardware
- Operator

3.2.2. System (Hazardous components)

- Fire/Flammability
  - Overheat/high temperature
  - Mechanical
- Electric shock
- Software
- Hardware
- Operator

4.0 RISK ASSESSMENT

4.1. APP System Hazard List

The Hazard List identifies the primary hazards and accident scenarios associated with the specific (sub)system being designed, describes the risk and estimates the probability of occurrence of a harm. The estimation of the risk considers the frequency and duration of the exposure of persons to the hazard, probability of occurrence of a hazardous event, the technical and human possibilities to avoid or limit the harm (e.g. emergency stop

equipment, reduced speed enabling device, awareness of risks) and severity of harm. In many cases these elements cannot exactly determined, but can only be estimated.

Where risk has been identified, the following measures are necessary to prevent injury.

- Assess Design Measures - Determine if measures are appropriate to level of risk. First, eliminate hazards by design, manage remaining risks, notify and train users on remaining risk.
- Verify Compatibility of Design Measures - Ensure that design features and measures will not defeat other measures or modes of operations.

Table 6: Detailed Hazard List

Potential Hazard	Severity	Probability	Scope	Comments
MECHANICAL HAZARDS (parts or workpieces)				
a) shape	N/A			
b) relative location	N/A			
c) mass and stability (potential energy of elements which may move under the effect of gravity)	N/A			
d) mass and velocity (kinetic energy of elements in controlled or uncontrolled motion) e) inadequacy of mechanical strength f) elastic elements (springs) g) liquids and gases under pressure h) the effect of vacuum	N/A N/A N/A N/A N/A N/A			
Crushing hazard	2	E	O	Applicable if earthquake or mishandling topples the H-Maser rack; probability minimized by bolting racks to under-floor supports designed for earthquake immunity
Shearing hazard	N/A			
cutting or severing hazard	4	E	O	Some risk is involved with handling modules and other system hardware.
entanglement hazard	N/A			.
drawing- in or trapping hazard	N/A			
impact hazard	N/A			
Stabbing	N/A			
friction or abrasion hazard	N/A			
high pressure fluid injection or ejection hazard	N/A			
ELECTRICAL HAZARD				

Potential Hazard	Severity	Probability	Scope	Comments
low voltage/high current	3	D	O	Shorting equipment rails could cause equipment damage and possible burns. LO Room has controlled access and locked doors on all equipment. Power supplies are fused and circuit breakers are present in the UPS. Personnel is trained. No jewelry or long hair permitted
exposed 115 V, 230 V	N/A			
approach to live parts under high voltage	N/A			
high power	N/A			
stored energy/capacitors	N/A			
stored energy/inductors	N/A			
electrostatic discharge including lightning	3	D	F	There is a potential for equipment damage from a person to electronics if a wrist strap is not properly worn. Maintenance protocols require ESD protection devices be used while servicing. Operational location and servicing to be conducted in a humidity controlled environment. Lightning suppression is not the responsibility of the APP.

Potential Hazard	Severity	Probability	Scope	Comments
battery	4	E	O	The Hydrogen Maser has a UPS
contact of persons with live parts (direct contact)	N/A			
contact of persons with parts which have become live under faulty conditions (indirect contact)	N/A			
thermal radiation or other phenomena such as the projection of molten particles and chemical effects from short circuits, overloads, etc.	N/A			
THERMAL HAZARDS				
radiation of heat sources (high temperature equipment)	N/A			
battery bank and UPS equipment	3	D	O	The Hydrogen Maser has a UPS. Over charging batteries could produce high heat.
flames or explosions	N/A			
HAZARDS GENERATED BY NOISE resulting in:				
hearing loss (deafness), other physiological disorders (e.g. loss of balance, loss of awareness)	N/A			
interference with speech communication, acoustic signals	N/A			
HAZARDS GENERATED BY VIBRATION				
use of hand-held machines resulting in a variety of neurological and vascular disorders	N/A			
whole body vibration, particularly when combines with poor postures	N/A			
HAZARDS GENERATED BY RADIATION				
X and gamma rays	N/A			

Potential Hazard	Severity	Probability	Scope	Comments
Lasers	4	E	O	Laser devices are used in the fiber optic communication transceivers. Short and long range transceivers are CL1, low power, infrared, and eye safe, with no protection needed. For comparison, CL1 is one grade safer than standard laser pointers, which are CL2.
low frequency, radio frequency radiation, micro waves	4	E	O	RF sources are present at 5, 10, 125 Mhz and also at 2 & 18 Ghz; all are below any harmful level, i.e., no more than 50 milli-watts
intense light sources	N/A			
radiation check sources	N/A			
HAZARDS GENERATED BY MATERIALS AND SUBSTANCES (and their constituent elements)				
hazards from contact with or inhalation of harmful fluids, gases, mists, fumes, and dusts	N/A			
fire and explosion hazard	N/A			
biological and microbiological (viral and bacterial) hazards (i.e., water)	N/A			
HAZARDS GENERATED BY NEGLECTING ERGONOMIC PRINCIPLES IN DESIGN as, e.g. hazards from:				
unhealthy postures or excessive effort	N/A			
inadequate consideration of hand-arm or foot-leg anatomy	N/A			
neglected use of personal protection equipment	N/A			
inadequate local lighting	N/A			
mental overload and underload, stress and strain	N/A			
human error, human behavior	N/A			
inadequate design or location of visual display units	N/A			
repetitive motion	N/A			

Potential Hazard	Severity	Probability	Scope	Comments
UNEXPECTED START-UP, UNEXPECTED OVERRUN/OVERSPEED (or any similar malfunction) from:				
failure/disorder of the control system	N/A			
restoration of energy supply after an interruption	N/A			
external influences (gravity, wind, etc.)	N/A			
errors in the software	N/A			
errors made by the operator (due to mismatch of machinery with human characteristics and abilities)	N/A			
systems redundancy and diversity	N/A			
interlocks	N/A			
OPERATING, TEST, MAINTENANCE AND EMERGENCY PROCEDURES				
human factors considerations	N/A			
adequacy and effectiveness of instruction, training	4	D	O	Only trained and authorized persons will be allowed to perform maintenance on the correlator
user error, including failure to activate	N/A			
effect of factors such as equipment layout, ergonomics and lighting	N/A			
crash safety, egress, rescue and survival	N/A			
variation in the speed of tools	N/A			
impossibility of stopping in the best possible condition	N/A			
MECHANICAL HAZARDS AND HAZARDOUS EVENTS				
loading/unloading (i.e., load falls, collisions, machine tipping)	3	D	O	At delivery and setup; racks and items over 25Kg should only be handled by persons trained with proper operation of material handling equipment
emergency response/spill clean-up	N/A			
packaging hazardous materials	N/A			
bad road conditions (e.g., icy)	N/A			
uncontrolled amplitude of movements	N/A			
inadequate holding devices/accessories	N/A			
insufficient mechanical strength of parts	N/A			
inadequate design of pulleys, drums	N/A			

Potential Hazard	Severity	Probability	Scope	Comments
inadequate selection of technical equipment and accessories and their inadequate integration	N/A			
abnormal conditions of assembly/testing/use/maintenance	N/A			
MOTION HAZARDS				
falling of person from person carrier	N/A			
moving vehicles, carts, forklifts	4	E	F	Forklift and operator will be supplied by ALMA Logistics during delivery. Installation related only.
material grinding, cutting, drilling	N/A			
work with roads and grounds equipment	N/A			
powered platforms	N/A			
overspeed of person carrier	N/A			
CHEMICAL HAZARDS				
acids, solvents, toxic agents and hazardous liquids	N/A			
heavy metals such as lead	N/A			
chemical reactions	N/A			
toxicity in smoke or fumes	N/A			
welding fumes	N/A			
carbon monoxide	N/A			
carcinogens	N/A			
chemical exposure	N/A			
PERSONNEL HAZARDS/ HAZARDS GENERATED BY NEGLECTING ERGONOMIC PRINCIPLES				
vacuum tanks	N/A			
pinch hazards	N/A			
confined spaces /insufficient means for evacuation/emergency exit	N/A			
restricted movement of persons	N/A			
lifting/carrying heavy objects	3	C	O	Some items may be > 25 kilograms. Two persons will be required to replace or handle these items and they shall be bear caution labels regarding their weight.

Potential Hazard	Severity	Probability	Scope	Comments
working at heights	N/A			
slips, trips & falls	N/A			
hazards requiring PPE	3	C	O	See additional entry in this section. Safety shoes shall be worn and site safety protocols observed where PPE is needed.
inadequate seating	N/A			
inadequate lighting	N/A			
insufficient visibility	N/A			
inadequate location of manual controls	N/A			
lack or inadequacy of visual or acoustic warning means	N/A			
CONSTRUCTION HAZARDS				
heavy equipment	N/A			
possibility of hitting utilities	N/A			
scaffolding	N/A			
ladder	N/A			
compressed gas	N/A			
earth moving equipment	N/A			
MATERIAL HANDLING HAZARDS				
ejected objects	N/A			
cranes & hoists	N/A			
fork lift operation	N/A			Some: addressed in Motion Hazards section above
chemical spills	N/A			
falling objects	N/A			
hazardous tools, equipment and machinery	N/A			
storage/handling of toxic materials	N/A			
ENVIRONMENTAL HAZARDS				
hazardous waste	N/A			
surface water discharges	N/A			
endangered species issues	N/A			
archeological requirements	N/A			
regulated chemical wastes	N/A			
groundwater protection	N/A			
ozone depleting substances	N/A			

Potential Hazard	Severity	Probability	Scope	Comments
sewer discharges	N/A			
drinking water quality	N/A			
FIRE HAZARDS				
electrical	1	E	F	Unavoidable use of electrical components and materials is expected. Circuit protection is designed in where needed for safety. ALMA site operations is responsible for fire protection.
flammable substances, solid, liquid or gaseous	N/A			
welding	N/A			
spark producing tools near combustibles	N/A			
spontaneous combustion	N/A			
storage of combustibles	N/A			
mobile structures (portakamps)	N/A			
transportation (rail, vehicle, fueling)	N/A			
boiler, furnace, heating systems and appliances	N/A			
stationary combustion engines	N/A			
cigarette smoking	N/A			
OXYGEN DEFICIENCY HAZARDS				
cryogenic spills	N/A			
cryogenic gas or liquid leak	N/A			
chemical spills	N/A			
leak of supplied gases	N/A			
HAZARDOUS COMPONENTS				
explosives	N/A			
asphyxiants, toxic or corrosive substances	N/A			
hazardous construction materials	N/A			
pressure systems	N/A			
hydraulic machinery	N/A			
other energy sources including motion	N/A			
hazardous surfaces	N/A			
FACTORS DUE TO OPERATING DOMAIN, OR THAT THE SYSTEM MAY ADD TO THE OPERATING DOMAIN				
drop	N/A			

Potential Hazard	Severity	Probability	Scope	Comments
shock and vibration, including seismic	N/A			
extreme pressures and climatic conditions	N/A			
noise	N/A			
exposure to toxic or corrosive substances	N/A			
ADEQUACY OF SAFETY RELATED EQUIPMENT, SAFEGUARDS AND FAILURE CONTAINMENT MEASURES				
relief valves	N/A			
energy containment vessels	N/A			
electrical protection	N/A			
toxic substance control	N/A			
electrical, air and hydraulic supplies	N/A			
personal protective equipment	N/A			
ventilation	3	C	F	Oxygen need at AOS during installation and checkout—ALMA Site operations is responsible for providing this.
noise or radiation barriers	N/A			
alarms and warnings	N/A			

4.1.1. Conclusions and Recommendations:

This section provides recommendations to address the risks identified in the Hazard List that require review and acceptance of the identified hazard and its controls solutions.

Risk	Recommendations
crushing hazard	This risk is addressed by the design of the seismic support for the CLOA, as designed by Southwest Research Institute. Also the use of proper equipment and technique by material handlers while moving the racks will prevent it from falling.
cutting or severing hazard	This is best addressed by administrative controls and training in conjunction with adherence to Site and Project Safety Policy. The frequency of this occurring is minimal.
low voltage/high current	This hazard is addressed by providing barriers where contact with conductors is possible, through education, by fuse limits on available power, by short circuit protection in power supplies, and through training.
electrostatic discharge/lightning hazard	Electrostatic discharge is managed by the humidification system and by educating maintenance personnel in the use of discharge prevention methods, primarily wrist straps. Lightning hazard is the responsibility of the site IPT.
Battery (Electrical . Risk)	A UPS employs 2 12V, 55Ah, sealed, lead acid batteries wired for 24V. Shock hazard is low, but the batteries are capable of high current and therefore are fused. Terminals shall be covered, caution labeling in place, and personnel trained in handling batteries.
Battery and UPS (Thermal Risk)	Over charging could generate heat. Thermal sensors are located in the BEND racks and shall configured to monitor internal rack temperatures.
lasers	Laser sources are CL1, low power, infrared, and eye safe, with no protection needed. For comparison, CL1 is one grade safer than standard laser pointers, which are CL2. Only trained and authorized personnel should be allowed to perform any type of maintenance or repair on any of the optical modules.
low frequency, radio frequency radiation,	Power levels are well below potentially harmful levels.

microwaves	
operating/test/maint/emerg effectiveness of training	The Hydrogen maser introduces a single point failure to the array, therefore only trained personnel shall be permitted to perform maintenance. It is located in a locked room with controlled access. In the event of a failure, the rubidium clock can be reconnected in place of the maser.
loading/unloading hazard	This is addressed in the shipping and installation plans. The hazard will be minimized by utilizing contractors for rack installation and including references to safety documents in related documents.
moving vehicles, carts, forklifts	Personnel provided by AIV should be adequately trained.
lifting /carrying heavy objects	This is best addressed by administrative controls and training, in conjunction with adherence to Site and Project Safety Policy. The frequency of this hazard is minimal.
Hazards requiring PPE	Related to item above, Safety shoes and gloves shall be used when handling items that are .25Kg or exhibit sharp or rough edges.
electrical fire hazard	Electrical components, cables, and COTs equipment shall be either CE or UL rated. Custom designs shall not expose electrical terminals and shall provide over current fault protection to guard against electrical shorts.
ventilation system	Sufficient oxygen must be provided for personnel safety, primarily during installation and checkout. This is an ALMA operations responsibility, but should be included in the installation plan and requested as a resource during installation. Room oxygenation is limited and shared between rooms at the AOS, so must be scheduled.

Table 7. Summary of risks and recommendations

4.2. APP System Hazard Analysis Process

The Hazard Analysis (HA) identifies safety critical areas, evaluates hazards, and identifies the design criteria to be used.

Hazard Analysis Considerations

The output of the Hazard Analysis (HA) is a detailed list of hazards associated with the design. The HA will consider the following for identification and evaluation of hazards as a minimum:

a. Hazardous components (e.g. electrical systems, cooling fluids, toxic substances, hazardous construction materials, pressure systems, lasers, and other energy sources).

b. Safety related interface considerations among various elements of the design, e.g. material compatibility, inadvertent activation, fire initiation and propagation. Design criteria to control safety-critical software commands and responses (e.g. inadvertent command, failure to command, untimely command or responses, or designated undesired events) shall be identified and appropriate action taken to incorporate them in the software and related hardware specifications.

c. Environmental constraints including transport, handling and operating environments, (e.g. drop, shock, vibration, extreme temperatures, noise, exposure to toxic substances, health hazards, fire, electrostatic discharge, lightning, electromagnetic environmental effects, and pressure).

d. Operating, testing, maintenance and emergency procedures (e.g. human error analysis, tasks, and requirements; factors such as equipment layout, lighting requirements, potential exposures to toxic materials, effects of noise or radiation on human performance, and environmental conditions).

e. Facilities, support equipment (e.g. provisions for storage, assembly, checkout, proof-testing of hazardous designs/assemblies which may include toxic, flammable, corrosive or cryogenic fluids; electrical power sources) and training (e.g. training and certification pertaining to safety operations and maintenance).

f. Safety related equipment, safeguards, and possible alternative approaches (e.g. interlocks, system redundancy, fail-safe design considerations, personal protective equipment, ventilation, and access barriers).

Table 8: Hazard Analysis Table

Number	Hazard Source	Cause Factors	Effects/ Severity	Severity	Occurrence Probability	Risk Index	Means for Prevention	ACTIONS/ REMARKS
1	crushing	rack falling due to earthquake or mishandling	personnel injury; equipment damage.	2	E	O	Rack is adequately secured to support, preventing it from falling. Use of proper equipment and techniques	There is only one rack to be installed and it will be empty until secured.
2	cutting or severing hazard	Risk to fingers and toes while handling equipment	personnel injury; equipment damage.	4	E	O	Use of PPE and material handling equipment	
3	low voltage/high current	shorting supply rails	minor/moderate equipment damage; possible burns	3	D	O	lockouts, barriers, education	
4	electrostatic discharge including lightning	Environmental conditions	personnel injury; equipment damage.	3	C	F	humidification, education, lightning suppression	
5	Battery (Electrical)	Shorted or exposed voltages	equipment damage.	4	E	O	Insulate terminals, label voltage points, education	
6	Battery and UPS	Over	Equipment	3	D	O	Monitor	

Number	Hazard Source	Cause Factors	Effects/ Severity	Severity	Occurrence Probability	Risk Index	Means for Prevention	ACTIONS/ REMARKS
	(Thermal)	Charging	damage, fire				temperature inside rack, shutdown on over temp.	
7	Lasers	IR Laser beam exposure	personnel injury	4	D	O	Labeling, Education	All devices are IEC Laser Class1
8	low frequency, radio frequency radiation, micro waves	RF sources are present at 5, 10, 125 Mhz and also at 2 & 18 Ghz. All are below harmful levels (no more than 50 milliwatts).	possible equipment malfunction due to unterminated outputs	4	E	O	Terminate all unused outputs. No risk of personal injury.	
9	operating/test/maint/emerg effectiveness of training	unauthorized access to equipment	minor equipment damage	4	D	O	Only trained and authorized persons will be allowed access to perform maintenance on the hydrogen maser.	
10	loading/unloading (i.e., load falls, collisions, machine tipping)	improper material handling	personnel injury; equipment	3	D	O	Use of proper equipment and	

Number	Hazard Source	Cause Factors	Effects/ Severity	Severity	Occurrence Probability	Risk Index	Means for Prevention	ACTIONS/ REMARKS
			damage.				techniques	
11	moving vehicles, carts, forklifts	untrained personnel, misuse of equip	personnel injury; equipment damage.	4	E	F	Forklift and operator supplied by ALMA.Log during delivery.	
12	lifting/carrying heavy objects	improper technique and equipment	personnel injury; equipment damage.	3	C	O	Use of proper equipment and techniques	
13	Hazards requiring PPE	Related to item directly above	personnel injury	3	C	O	Use of proper equipment and techniques	Safety shoes and gloves are recommended
14	electrical fire hazard	inadequate design, improper installation, carelessness	catastrophic damage to equipment or personnel	1	E	F	Specify CE & UL rating for COTS, design for circuit protection, installation to codes, education	
15	ventilation	diminished oxygen levels at AOS	minor personnel injury	3	C	F	Plan for room oxygenation, monitor O2 blood levels, carry personal O2	

Table 9 Certifications

Item	Certifications
I3000 Maser	CE EN 55022-B (Radiated and conducted EMI)
	CE EN 55024 (Information)
	CE EN 61326-1 (Equipment for measurement, control, lab use)
Xytronix Research X-DAQ-2R1-4T-E, web enabled temperature monitor (Proposed)	FCC 47CFR15 Class B, IEC CISPR 22, CISPR 24 (EMC), EN55024, EN55022 (EU EMC)
	Safety IEC 60950-1 / EN 60950-1
Eaton-Pulizzi TPC2365/MTD intelligent power strip (Proposed)	TUV Rheinland (C US) of NA, CE, RoHS 2002/95/CE
WD Black & Blue Disk Drives	Canada ICES-003 Class B / NMB-003 Class B (EMC)
	CE (directives unspecified in data sheet)
	RoHS Directive 2011/65/EU
Cosel PBA10F Power Supply in XW-100 Optical chassis	UL “Recognized Component”
	FCC Part15 classB
	CE EN55022-B, EN55011-B (Radiated and conducted EMI)
	Japan VCCI-B (Radiated and conducted EMI)
	UL60950-1, C-UL(CSA60950-1), EN60950-1, EN50178 Complies with DEN-AN
San Ace 80, fan in XW-100 Optical chassis	Flammability: UL94V-0 (frame), UL94V-1 (impeller)
	UL “Recognized Component”, UL Certified
	RoHS 2002/95/EC
	CSA Certification
	TUV EN 61058-1, for low voltage appliances
Sumitomo 10GB-SR SXP3100SX optical	CL 1 Laser Compliant per FDA, EN (IEC) 60825 (and FDA)

transceiver in XW-100 Chassis (Preliminary)	
	RoHS 2002/95/EC
	FCC Class B, per CENELEC EN50 081 and 082
	IEC 61000-4-3 (80- 1000MHz, Test Level 3) and GR-1089 (RFI Immunity)
	IEC 61000-4-2 (ESD Immunity)
Sumitomo 10GB-XR SXP3102DA-Fxxx optical transceiver in XW-100 Chassis (Preliminary)	Laser Safety Class 1 per IEC60825-1 and FDA/CDRH 21 CFR 1040
Mellanox Optical transceiver, MFM1T02A-SR	Laser safety Class 1 per EN (IEC) 60825 (and FDA),TUV and CSA
	Electrical Safety EN (IEC) 60950
Sunpower ATX PS	EMI: EN 55022 CLASSB, FCC CFR 47 PART 15 CLASS B, CNS 13438. CLASS B, Compliance to EN61000-3-2 CLASSD, EN61000-3-3
	EN 55024: EN 61000-4-2,3,4,5,6,8,11
	UL 60950-1 2nd, GSA C22.2 No. 60950-1-07 2nd, TUV EN 60950-1 :2006+A11, IEC 60950-1:2005, approved
GPS Receiver, XLi	UL, C-UL: UL 1950/CSA 22.2 950, Standard for Safety, Information Technology Equipment (ITE)
	FCC Part 15, Subpart B
	89/336/EEC EMC Directive 73/23/EEC Low Voltage Safety Directive IEC 60950 Safety of Information Technology Equipment (ITE)

5.0 SUMMARY

- No conditions are identified as Unacceptable.
- A few conditions are identified as Undesirable which can all be mitigated through implementation and installation of remaining work packages.

- Items highlighted in yellow and blue shall be reviewed by APP Engineers and management to ensure all of these items are mitigated to the satisfaction of JAO.