Antenna Electronics Environmental Control System Reference Design Description

020.30.60.00.00-0002-DSN-A-ENVIR_CONTROL_REF_DESIGN

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PREPARED BY	ORGANIZATION	DATE
D. Gerrard, S. Sturgis, and J. Allison	Electronics Div., NRAO	2018-11-12
S. Durand, Antenna Electronics IPT Lead	Electronics Div., NRAO	2019-05-04

APPROVALS (Name and Signature)	ORGANIZATION	DATE
R. Selina, Project Engineer R. Selina 2019.07.23 12:40:36 -06'00'	Electronics Div., NRAO	2019-07-23
M. McKinnon, Project Director Mark McKinnon Digitally signed by Mark McKinnon Date: 2019.07.23 14:02:11 -06'00'	Asst. Director, NM-Operations, NRAO	2019-07-23

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M. McKinnon, Project Director Mark McKinnon Digitally signed by Mark McKinnon Date: 2019.07.23 14:02:27 -06'00'	Asst. Director, NM-Operations, NRAO	2019-07-23

Change Record

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02	2018-07-10	J. Allison	5	Added design descriptions
03	2018-07-12	S. Sturgis	All	Updated and revised all sections
04	2018-09-21	S. Sturgis	All	Updates throughout to better reflect the current design
05	2018-09-21	S. Durand	All	Small Edits
06	2018-10-09	J. Allison	4, 5	Addressed RID numbers: IPDSR-10, IPDSR-11, IPDSR-12, IPDSR-15, IPDSR-16
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1 Introduction

1.1 Purpose

This document provides a description for the Antenna Electronics Environmental Control system reference design. It covers the design approach, functions, description of key components, interfaces, and risks associated with the reference design. This document will form part of the submission of the ngVLA Reference Design documentation package.

1.2 Scope

The scope of this document covers the entire design of the Antenna Electronics Environmental Control system, as part of the ngVLA Reference Design. It includes the system's design, how it functions, and interfaces with the necessary hardware and software systems.

It does not include specific technical requirements or budgetary information.

2 Related Documents and Drawings

2.1 Applicable Documents

The following documents may not be directly referenced herein, but provide necessary context or supporting material.

Reference No.	Document Title	Rev/Doc. No.
AD01	ngVLA Preliminary System Requirements	V1.0, 3/30/2017
AD02	ngVLA Environmental Specifications	020.10.15.10.00-0001-SPE
AD03	ngVLA Antenna Electronics Environmental Control System: Preliminary Technical Requirements	020.30.60.00.00-0001-REQ

2.2 Reference Documents

The following documents are referenced within this text:

Reference No.	Document Title	Rev/Doc. No.
RD01	ngVLA Cryogenic Subsystem Requirements	020.30.10.00.00.0001-REQ
RD02	ngVLA Integrated Receivers and Downconverters: Preliminary Technical Specifications/Requirements	020.30.15.00.00-0001-REQ
RD03	ngVLA Water Vapor Radiometer Preliminary Technical Requirements	020.45.00.00.00-0001-REQ

3 Antenna Electronics Environmental Control System Overview

The antenna electronics are located in various places around the antenna. Primary locations include but are not limited to the electronics rack in the pedestal room, the Receiver and Auxiliary Enclosures on the feed arm, the WVR enclosure near the base of the feed arm, and the compressor platform/enclosure at the top rear of the pedestal. Environmental control of the antenna electronics consists of temperature control of all the electronics in these locations as well as protection from water, dust, animals, or other environmental hazards.

There are two temperature control systems for the antenna electronics: a hot/cold liquid loop above the azimuth axis and a traditional air-cooling unit in the pedestal room. The first consists of a hot/cold liquid loop, most likely glycol, which runs from a chiller unit at the top-rear of the pedestal to the WVR Enclosure, and the front end Receiver and Auxiliary Enclosures. At each location a local liquid hot/cold plate that consists of copper tubing running through an aluminum block, which components may be directly mounted to, will cool components in both the front end enclosures and the WVR enclosure, as well as on the compressor platform/enclosure.

The pedestal room electronics rack will be forced-air-cooled via a local air handler unit to force cold air through the rack from bottom to top. This system will likely be closed loop so that it does not have to cool the entire pedestal room.

Protection from water, dust, animals, or other environmental hazards will be provided by custom designed Front End Receiver, Auxiliary, WVR, and compressor platform enclosures as necessary, and an electronics rack in the pedestal room.

4 Antenna Electronics Environmental Control System Design

There are three main parts to the Antenna Electronics Environmental Control system: the hot/cold liquid loop, the cold air blower, and the environmental enclosures. The hot/cold liquid loop was chosen because it is much easier to move heat around the antenna via a dense liquid than it is via air.

The cold air blower was chosen because the modules in the electronics rack require air-cooling, and it was undesirable to run a cold liquid line through the azimuth wrap/axis.

The temperature regulation requirements are tabulated by component and location below:

Location	Component	Operational Temp Range [C]	Temp Grad [C/hr]	Heat Dissipation [W]
FE Receiver Enclosure	IRD Module	–15 to 35 [RD02]	3.6 [RD02]	115
	P501 Module	N/A	N/A	195
FE Auxiliary Enclosure	Vacuum Pump	12 to 45 [RD01]	N/A	TBD
Compressor Platform	Helium Compressor	–30 to 45 [RD01]	N/A	TBD
	Cryo M&C Cold Plate	TBD	N/A	200
	Glycol Chiller	TBD	N/A	TBD
	Cryo M&C Module	TBD	N/A	TBD
WVR Receiver Enclosure	Component Cold Plate	>28	0.02	20 [RD03]
	P502 Module	N/A	N/A	145
Back End Rack	D501 Module	N/A	N/A	TBD
	F518 Module	N/A	N/A	100
	M500 Module	N/A	N/A	75
	M501 Module	N/A	N/A	75
	P500 Module	N/A	N/A	165
	P503 Module	N/A	N/A	145

These are preliminary numbers which will likely change during the development of the conceptual design

4.1 Temperature Control Components

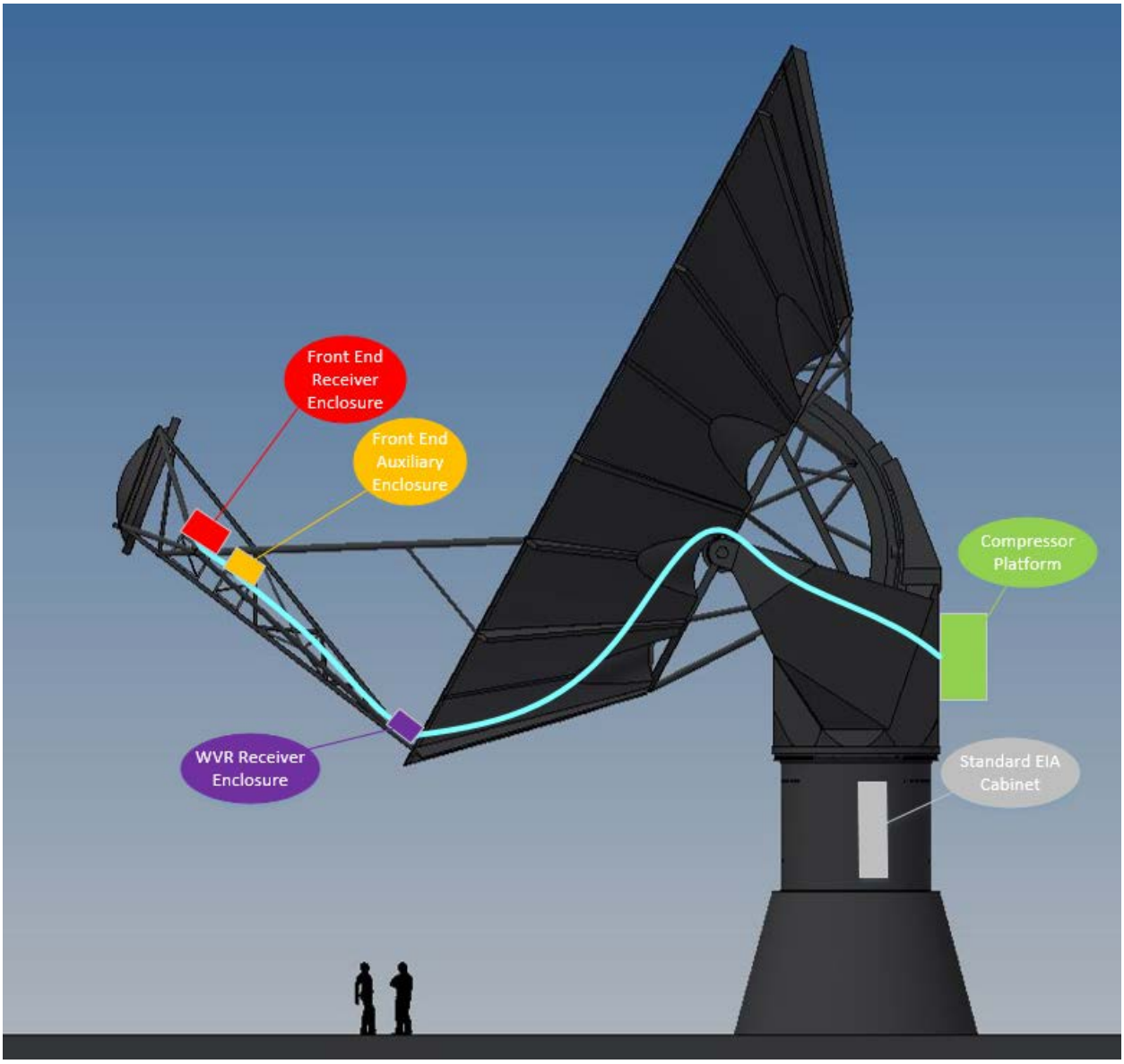

Figure 1 - Locations of antenna electronics environmental control system components.

4.1.1 Liquid Loop Chiller

There will be an air-cooled chiller unit to cool the liquid (glycol) located on the compressor platform/enclosure. The chiller shall be capable of delivering +/-1 degree C glycol to all required components.

4.1.2 Liquid Loop Heater

The glycol chiller shall be capable of both cooling and heating of the glycol.

4.1.3 Liquid Hot/Cold Plate

There will be multiple liquid hot/cold plates located in the front end receiver enclosure to cool the IRD enclosure, the P501 Module, and the general environment of the enclosure as well as any other components that may require cooling. The IRD module in the receiver enclosure will require a high level of precise temperature control (0.1°C/20min), which is more precise than the chiller can provide. The higher precision will be achieved with locally located thermoelectric modules.

There will be a liquid hot/cold plate in the WVR receiver enclosure. The temperature control in the WVR enclosure will require a high level of precise temperature control (0.05°C/hour), which is more precise than the chiller can provide. The higher precision will be achieved with locally located thermoelectric modules.

There will be multiple liquid hot/cold plates located in the auxiliary front end enclosure for cooling components, the full list of which is TBD. The temperature control in the auxiliary enclosure will only require an average level of temperature control (+/-1°C/hour) and will be achieved with the chilled glycol.

There will be a liquid hot/cold plate on the compressor platform for heating or cooling the M&C module. The temperature control for the Cryo M&C module will only require an average level of temperature control (+/-1°C/hour) and will be achieved with the chilled glycol.

4.1.4 Air Handler

There will be an air handler unit located in the pedestal room to force air through the electronics rack. This is anticipated to be a closed loop system so that the air handler does not cool the entire pedestal room but only the electronics rack and any associated equipment. Furthermore, the air handler's heat exchanger may require venting to outside of the pedestal room, depending on how well the room is sealed/insulated. The pedestal room electronics rack will only require an average level of temperature control (+/-1°C/hour).

4.1.5 Receiver Enclosure Heater

To combat condensation on the front of the receiver windows, there will be heaters located on the front of the environmental receiver enclosure in such a way as to not interfere with the receivers operation.

4.2 Hazard Control Components

4.2.1 Front End Receiver Enclosure

The front end electronics located on the feed arm of the antenna will be housed in environmentally sealed enclosures to protect them from water and debris. The Receiver Enclosure will house Dewars A & B, the IRD Enclosure, the P501 Module, and the M&C for both Dewars and will be made up of a welded aluminum frame with removable panels on all sides so that the housed components may be easily accessed for maintenance.

The removable panels will have lockable push-to-close latches and will be located on all sides of the enclosure except for the bottom and the side facing the secondary reflector. The enclosure will have one fixed plate on the rear side where permanent connections to other systems will be located. This will help minimize external connectors and simplify the installation and removal of housed +. The removable panels will be made of an aluminum composite panel, with thin sheets of aluminum on either side of corrugated plastic. Their edges will be lined with aluminum U-channels which will stiffen the entire panel. Each panel will also have a layer of insulation on the inside to maintain temperature inside of the enclosure. The frames will have environmental seals where all removable panels are installed to protect the components

from water, dust, and debris. This enclosure is designed to only protect from environmental hazards. All housed components requiring RFI shielding will have their own RFI tight packaging inside of this enclosure.

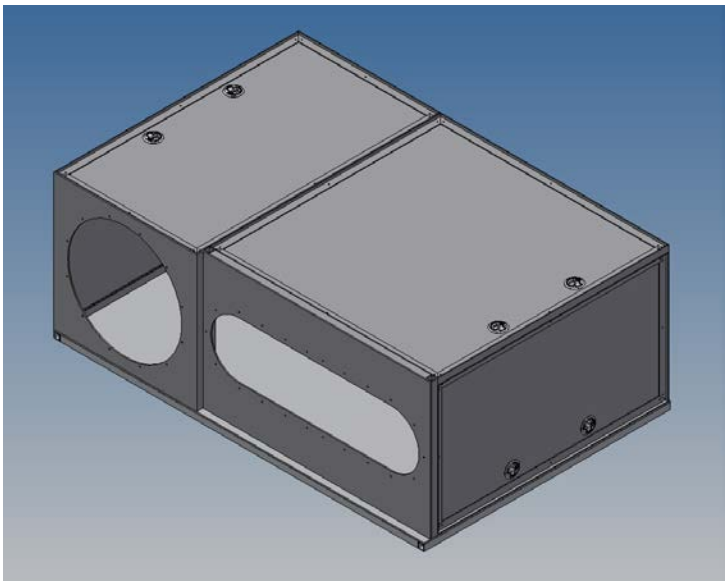

Figure 2 - Front End receiver enclosure.

4.2.2 Front End Auxiliary Enclosure

The Auxiliary Enclosure will be located on the feed arm near to the Receiver Enclosure and will be based on the same design as the Receiver enclosure.

The Auxiliary Enclosure will house any equipment the receivers need to function that doesn't need to be co-located with the receivers. Having this enclosure allows us to minimize the amount of mass being shifted around at the end of the antenna arm.

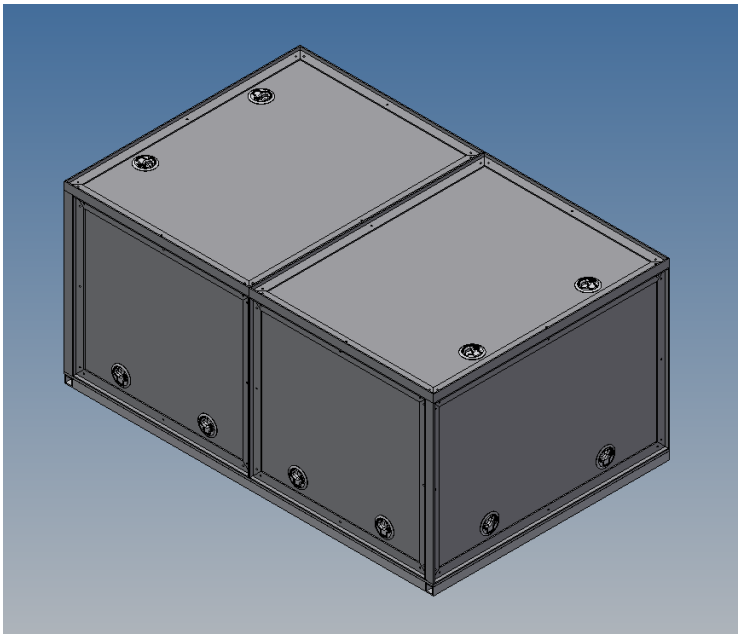

Figure 3 - Front End auxiliary enclosure.

4.2.3 WVR Enclosure

The WVR Enclosure will likely be a welded box located somewhere along the edge of the antenna's main reflector, possibly near to the base of the feed arm. The exact location is still to be determined, based on physical interference between surrounding antennas and signal interference from the structure of the host antenna.

4.2.4 Compressor Platform/Enclosure

The Compressor Platform/Enclosure is located near the top rear of the pedestal and holds the cryogenic helium compressor, the liquid glycol chiller and heater, and an RFI-tight cryogenics M&C module. Depending on the helium compressor's environmental requirements, this may be more of a vented enclosure than an open platform. If built as an enclosure it will be similar in design to the Front End Auxiliary Enclosure.

4.2.5 Pedestal Room Rack

The Pedestal room rack (provide by the Bins, Modules & Racks work package) will be located in the pedestal room and will house all of the modules for the Antenna Electronics that are not housed in the front end, WVR, or compressor enclosure. The current plan is to use a single 19inch rack, but depending on the size of the pedestal room and the number of modules housed this may be expanded to two smaller racks. Smaller racks may be shorter, shallower or both. The standard sized rack is the preferred option. The modules inside of the rack will be cooled using a closed loop forced air system (provided as part of this Antenna Electronics Environmental Control work package) with the air entering the bottom of the rack, being directed past the heatsinks on the modules, and then being recirculated out of the top of the rack and back to the air handler unit.

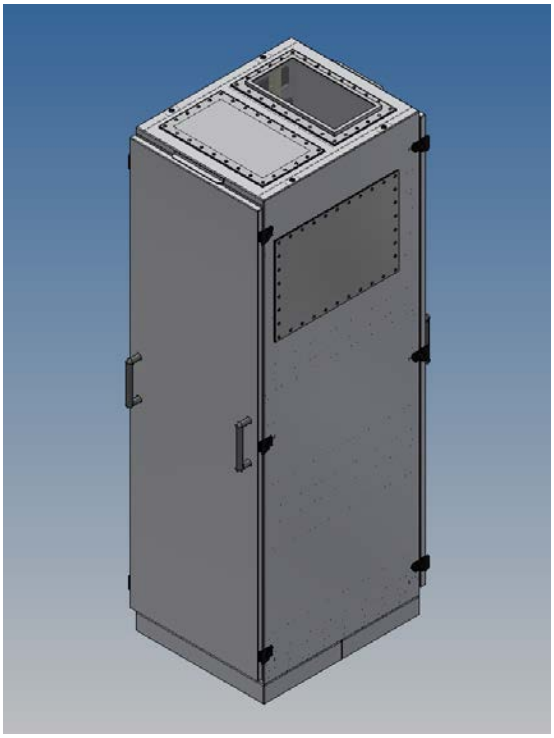

Figure 3 - Pedestal room rack.

4.3 Interfaces with Other Subsystems

The Environmental Control system will have interfaces as follows:

- Pedestal room
  - ICD between air handler and electronics rack
  - ICD between air handler and antenna
- Compressor platform/enclosure
  - ICD between enclosure and antenna
  - ICD between enclosure and cryogenic compressor
  - ICD between enclosure and glycol chiller
- WVR
  - ICD between environmental enclosure and antenna
  - ICD between environmental control system and WVR subsystem
- Auxiliary front end enclosure
  - ICD between auxiliary front end enclosure and antenna
  - ICD between auxiliary front end enclosure and TBD equipment housed within it
- Receiver Front end enclosure
  - ICD between receiver front end enclosure and antenna
  - ICD between receiver front end enclosure and Dewar A LRU
  - ICD between receiver front end enclosure and Dewar B LRU
  - ICD between receiver front end enclosure and P501 Module
  - ICD between receiver front end enclosure and TBD equipment housed within it

5 Appendix

5.1 Acronyms and Abbreviations

Acronym	Description
AD	Applicable Document
DBE	Digital Back End
DTS	Data Transmission System
IF	Intermediate Frequency
LO	Local Oscillator
LRU	Line Replaceable Unit
M&C, M/C	Monitor and Control
NES	Near Earth Sensing
ngVLA	Next Generation VLA
NSF	National Science Foundation
PLL	Phase Locked Loop
RD	Reference Document
RF	Radio Frequency
TBD	To Be Determined
VLA	Jansky Very Large Array
WVR	Water Vapor Radiometer