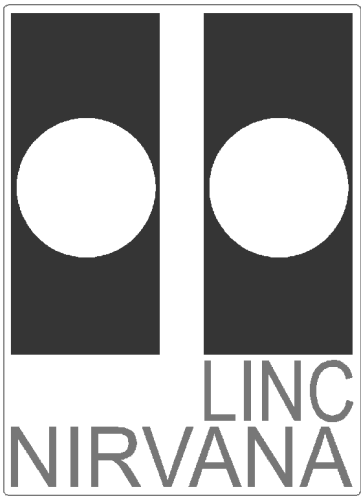
LINC-NIRVANA

The **L**BT **IN**terferometric **C**amera and
Near-**I**nfra**R**ed / **V**isible **A**daptive
i**N**terferometer for **A**stronomy

A collaborative project of the MPIA Heidelberg, INAF-Arcetri,
Universität zu Köln, and MPIfR Bonn

http://www.mpia.de/LINC



LINC-NIRVANA

-

Safety and Hazard Management

Doc. No.	LN-MPIA-FDR-GEN-006
Short Title	Safety
Issue	1.0
Date	12 June 2005

Prepared	T. M. Herbst	3 January 2004	
	Name	Date	Signature
Approved	M. Kürster	6 June 2005	
	Name	Date	Signature
Released	M. Kürster	13 June 2005	
	Name	Date	Signature

Document Change Record

Issue	Date	Section/ Paragraph Affected	Reasons / Remarks
0.1 1.0	3 January 2005 13 June 2005	All All	TMH – new document Approver's comments

TABLE OF CONTENTS

1 Scope

This document addresses potential risks to LBT observatory personnel presented by the LINC-NIRVANA instrument, as well as potential hazards to the instrument itself. We characterize these risks both by their severity and by how frequently they are likely to occur. In all instances, a priori and a posteriori mitigation measures can reduce the impact of hazardous events.

2 Applicable documents

No.	Title	Number & Issue
1	LINC-NIRVANA Preliminary Design Review	N/A
2	Science-Technical Requirements	LN-MPIA-FDR-GEN-003
3	Operations / Maintenance Requirements	LN-MPIA-FDR-GEN-004

3 External Interfaces

Item	Short descrition
Not applicable	

4 Acronyms and abbreviations

HW	Hardware
PDR	Preliminary Design Review
SW	Software

5 Introduction

LINC-NIRVANA is a large, complicated instrument with a substantial number of subsystems. The assembly and operation of such an instrument inevitably involves some risk to personnel, observatory facilities, and LINC-NIRVANA itself. In this chapter, we address safety and hazard management.

6 Categorization of Risk

Each risk factor has an associated assessment of the gravity or seriousness of the event, and of how often it is likely to occur. Clearly high risk, high likelihood events are unacceptable, but there are no formal LBT requirements in this area. We therefore base our safety assessment on a

system similar to that developed at the European Southern Observatory (document VLT-SPE-ESO-10000-0017).

6.1 Hazard Severity Categories

The following table defines the categories for hazard severity:

Category	Description	Definition (personnel)	Definition (equipment)
1	Catastrophic	Death	Equipment cannot be recovered at reasonable cost, or is out of operation for more than 4 weeks
2	Critical	Severe injury or severe occupational illness	Equipment can be recovered with outside assistance and/or a period less than 4 weeks is necessary
3	Marginal	Minor injury or minor occupational illness	Equipment can be repaired by LBTO staff and/or is out of operation for up to one week
4	Negligible	Very minor injury or very minor occupational illness	Equipment can be readily repaired in less than one day by LBTO staff

6.2 Hazard Probability Categories

The following table defines the categories of likelihood of occurrence for hazardous events:

Category	Likelihood	Description
A	Frequent	Likely to occur more than once per year
B	Probable	Will occur 6-10 times during the lifetime of the instrument
C	Occasional	Will occur 2-5 times during the lifetime of the instrument
D	Remore	Unlikely, but possible to occur once during the instrument lifetime
E	Improbable	So unlikely that it can be assumed never to occur

6.3 Hazard Acceptability Criteria

Clearly, catastrophic or frequent hazards are unacceptable, yet there is no way to guarantee zero risk for all occurrences. The following table establishes combined severity-likelihood categories, and sets standards for acceptability by the LBT Observatory:

	1 - Catastrophic	2 - Critical	3 - Marginal	4 - Negligible
A- Frequent	**1/A**	**2/A**	**3/A**	**4/A**
B - Probable	**1/B**	**2/B**	**3/B**	**4/B**
C - Occastional	**1/C**	**2/C**	**3/C**	**4/C**
D - Remote	**1/D**	**2/D**	**3/D**	**4/D**
E - Improbable	**1/E**	**2/E**	**3/E**	**4/E**

Acceptability Categories:

Unacceptable risk under any circumstances
Undesirable, requiring explicit LBTO approval
Acceptable, but should be reviewed by LBTO
Acceptable without LBT Observatory review

7 LINC-NIRVANA Hazard Analysis

This section lists potential hazards associated with LINC-NIRVANA. These include potential risks to personnel and equipment (P / E in list below), as well as an assessment of the severity and likelihood of the event. The items also include mitigation measures to reduce these hazards.

Since LINC-NIRVANA is such a large and complex instrument, we evaluate the hazards on a component by component basis. Figure 7.1 shows the logical breakdown of the instrument for this purpose.

7.1 Optical Bench and Substructure

Hazard: (P/E) Accident during transportation and installation
Category: 1/E – Catastrophic / Improbable
Mitigation: Proper handling procedures, skilled crane operators

Hazard: (E) Collision of equipment with bench and substructure
Category: 2-4/D Critical-Negligible / Remote to
Mitigation: Proper handling procedures, instrument protective housing

Hazard: (P) Collision of personnel with bench and substructure
Category: 4/B Negligible / Probable
Mitigation: Warning markers (yellow/black), protective headgear

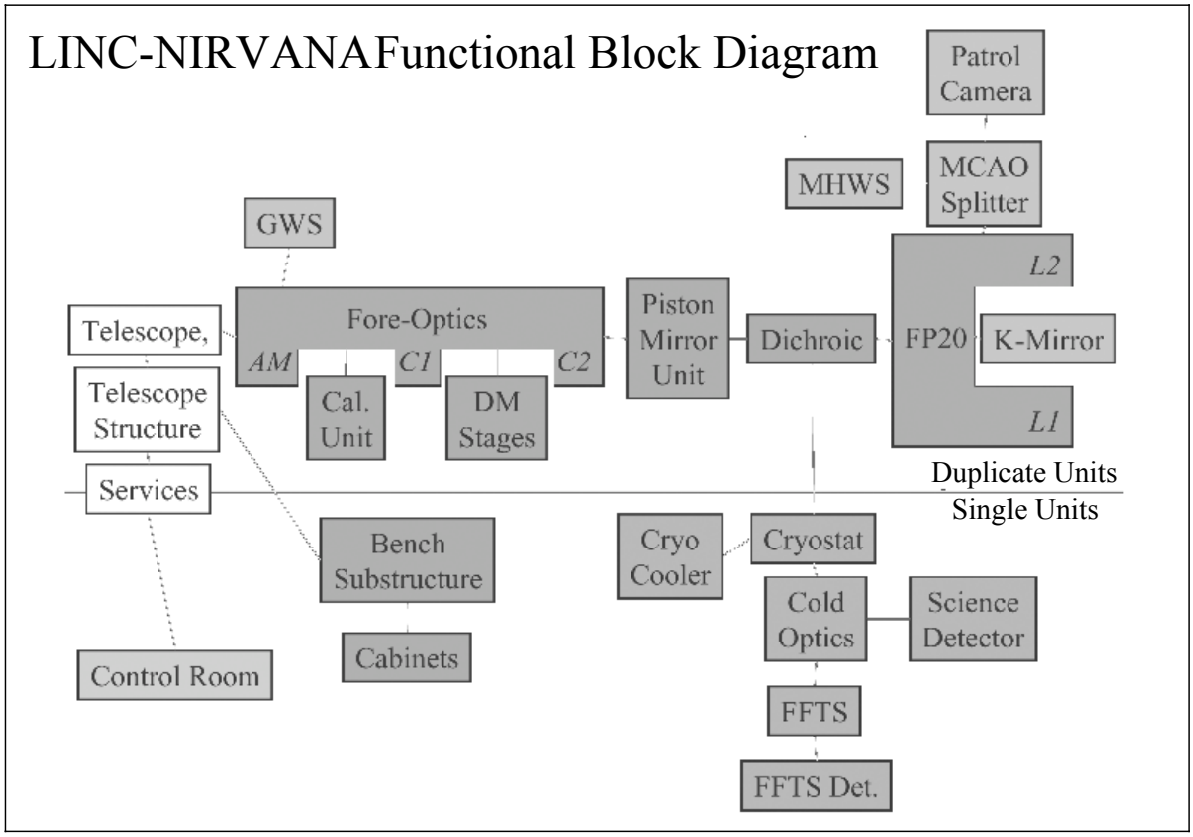


Figure 7.1 – Functional Block Diagram of LINC-NIRVANA

7.2 Warm Fore-optics

This includes the annular mirror (AM), and the two lens groups associated with the collimator (C1, C2).

Hazard: (E) Dropping or impacting optical components
Category: 1-2/E – Catastrophic-Critical / Improbable
Mitigation: Proper shipping and handling procedures, protective instrument housing

Hazard: (E) Contamination of optical surfaces
Category: 4/B – Negligible/Probable
Mitigation: Cleanliness procedures, protective instrument housing

7.3 DM Stages

Hazard: (E) Dropping or impacting deformable mirrors

Category: 1-2/E – Catastrophic-Critical / Improbable

Mitigation: Proper shipping and handling procedures, mirror covers, protective instrument housing

Hazard: (E) Contamination of optical surfaces

Category: 4/B – Negligible/Probable

Mitigation: Cleanliness procedures, protective instrument housing

Hazard: (P) Crushing or pinching of extremities during mechanical stage motions

Category: 3/D – Marginal / Remote

Mitigation: Proper procedures, Emergency stop buttons

7.4 Piston Mirror Unit

Hazard: (E) Dropping or impacting piston mirror

Category: 1-2/E – Catastrophic-Critical / Improbable

Mitigation: Proper shipping and handling procedures, mirror cover, protective instrument housing

Hazard: (E) Contamination of optical surfaces

Category: 4/B – Negligible/Probable

Mitigation: Cleanliness procedures, protective instrument housing

7.5 Dichroic Assembly

Hazard: (E) Dropping or impacting dichroic mirrors

Category: 1-2/E – Catastrophic-Critical / Improbable

Mitigation: Proper shipping and handling procedures, protective instrument housing

Hazard: (E) Contamination of optical surfaces

Category: 4/B – Negligible/Probable

Mitigation: Cleanliness procedures, protective instrument housing

7.6 Cold Optics

Hazard: (E) Thermal shock

Category: 1-2/E – Catastrophic-Critical / Improbable

Mitigation: Temperature control, cryogenic design, compliant mountings, material selection

Hazard: (E) Damage by window implosion debris

Category: 2/E – Critical / Improbable

Mitigation: Overspecification of window, proper vacuum procedures

Hazard: (E) Dropping or impacting cold optics

Category: 1-2/E – Catastrophic-Critical / Improbable
Mitigation: Proper shipping and handling procedures

7.7 Science Detector

Hazard: (E) Thermal shock
Category: 1-2/E – Catastrophic-Critical / Improbable
Mitigation: Temperature control, thermal mass

Hazard: (E) Electrostatic damage
Category: 1/E – Catastrophic / Improbable
Mitigation: Proper electrostatic handling procedures

7.8 Fringe and Flexure Tracker Optomechanics

Hazard: (E) Dropping or impacting cold optics
Category: 1-2/E – Catastrophic-Critical / Improbable
Mitigation: Proper shipping and handling procedures, interlocks

Hazard: (E) Mechanical damage due to jammed or interfering parts
Category: 2-3/D – Critical-Marginal / Remote
Mitigation: Hardware and software interlocks, thorough testing

Hazard: (P) Crushing or pinching of extremities during mechanical stage motions (during testing phase only)
Category: 3/D – Marginal / Remote
Mitigation: Proper procedures, Emergency stop buttons

7.9 Fringe and Flexure Tracker Detector

Hazard: (E) Thermal shock to detector
Category: 1-2/E – Catastrophic-Critical / Improbable
Mitigation: Temperature control, thermal mass

Hazard: (E) Electrostatic damage to detector
Category: 1/E – Catastrophic / Improbable
Mitigation: Proper electrostatic handling procedures

7.10 Cryostat

Hazard: (E) Implosion of vacuum vessel
Category: 1/E – Catastrophic/Improbable
Mitigation: Over-specification in design of vessel and entrance windows

Hazard: (P) Injury due to implosion of vacuum vessel
Category: 2-3/E – Critical-Marginal/Improbable
Mitigation: Over-specification in design of vessel and entrance windows

Hazard: (P/E) Explosion of vacuum vessel
Category: 1/E – Catastrophic/Improbable
Mitigation: Over-specification in design of vessel, burst valve, emergency pumping

Hazard: (E) Failure of roughing or turbomolecular pump
Category: 3/D – Marginal/Remote
Mitigation: Software interlocks, emergency pumping procedures

Hazard: (E) Contamination of cold components (including 7.6-7.9 above)
Category: 4/C – Negligible/Occastional
Mitigation: Clean-room conditions for working in cryostat

7.11 Cryo-Cooler

Hazard: (P/E) Accident during transportation, installation, or removal of compressor/controller
Category: 1/E – Catastrophic / Improbable
Mitigation: Proper handling procedures, skilled crane operators

Hazard: (P) Electrocution by compressor/controller
Category: 1-2/E – Catastrophic-Critical / Improbable
Mitigation: Proper procedures, safety standards compliance, interlocks, warning labels, emergency shutoff button

Hazard: (E) Contamination of cryogenic fluids
Category: 3/C – Marginal/Occasional
Mitigation: Regular maintenance

Hazard: (E) Leakage of cryogenic fluids inside cryostat
Category: 2-3/D – Critical-Marginal/Remote
Mitigation: Design, leak testing, emergency pumping

Hazard: (E) Leakage of cryogenic fluids outside cryostat
Category: 3/C – Marginal/Occasional

Mitigation: Design, regular maintenance, proper cryogenic procedures

Hazard: (P) Injury due to contact with cryogenic fluids
Category: 3-4/C – Marginal-Negligible/Occasional
Mitigation: Proper cryogenic handling procedures, localization and repair of leaks

7.12 FP 20 Optics

This includes the field-rotation “K Mirror”

Hazard: (E) Dropping or impacting optical components
Category: 1-2/E – Catastrophic-Critical / Improbable
Mitigation: Proper shipping and handling procedures, protective instrument housing

Hazard: (E) Contamination of optical surfaces
Category: 4/B – Negligible/Probable
Mitigation: Cleanliness procedures, protective instrument housing

7.13 Ground-Layer Wavefront Sensor

Hazard: (P/E) Accident during transportation, installation, or removal
Category: 1/E – Catastrophic / Improbable
Mitigation: Proper handling procedures, skilled crane operators

Hazard: (P) Crushing or pinching of extremities during mechanical stage motions
Category: 3/D – Marginal / Remote
Mitigation: Proper procedures, Emergency stop buttons

Hazard: (E) Dropping or impacting optical components
Category: 1-2/E – Catastrophic-Critical / Improbable
Mitigation: Proper shipping and handling procedures, software and hardware interlocks

Hazard: (E) Contamination of optical surfaces
Category: 4/B – Negligible/Probable
Mitigation: Cleanliness procedures

7.14 Mid-High Layer Wavefront Sensor

Hazard: (P/E) Accident during transportation, installation, or removal
Category: 1/E – Catastrophic / Improbable
Mitigation: Proper handling procedures, skilled crane operators

Hazard: (P) Crushing or pinching of extremities during mechanical stage motions
Category: 3/D – Marginal / Remote
Mitigation: Proper procedures, Emergency stop buttons

Hazard: (E) Dropping or impacting optical components
Category: 1-2/E – Catastrophic-Critical / Improbable
Mitigation: Proper shipping and handling procedures, software and hardware interlocks, instrument protective housing

Hazard: (E) Contamination of optical surfaces
Category: 4/B – Negligible/Probable
Mitigation: Cleanliness procedures, instrument protective housing

7.15 Patrol Camera

Hazard: (E) Dropping or impacting optical components
Category: 1-2/E – Catastrophic-Critical / Improbable
Mitigation: Proper shipping and handling procedures, instrument protective housing

Hazard: (E) Contamination of optical surfaces
Category: 4/B – Negligible/Probable
Mitigation: Cleanliness procedures, instrument protective housing

Hazard: (E) Thermal shock to detector
Category: 1-2/E – Catastrophic-Critical / Improbable
Mitigation: Temperature control, thermal mass

Hazard: (E) Electrostatic damage to detector
Category: 1/E – Catastrophic / Improbable
Mitigation: Proper electrostatic handling procedures

Hazard: (E) Damage by window implosion debris
Category: 2/E – Critical / Improbable
Mitigation: Overspecification of window, proper vacuum procedures

7.16 Calibration Unit

Hazard: (P) Crushing or pinching of extremities during mechanical stage motions
Category: 3/D – Marginal / Remote
Mitigation: Proper procedures, Emergency stop buttons

Hazard: (E) Dropping or impacting optical components
Category: 1-2/E – Catastrophic-Critical / Improbable

Mitigation: Proper shipping and handling procedures, protective instrument housing

Hazard: (E) Contamination of optical surfaces
Category: 4/B – Negligible/Probable
Mitigation: Cleanliness procedures, protective instrument housing

Hazard: (P) Eye injury from laser radiation
Category: 3/D – Marginal/Remote
Mitigation: Safety procedures, low energy density, protective housing

7.17 Electronics Cabinets

Hazard: (P/E) Accident during transportation, installation, or removal
Category: 1/E – Catastrophic / Improbable
Mitigation: Proper handling procedures, skilled crane operators

Hazard: (P) Electrocution
Category: 1-2/E – Catastrophic-Critical / Improbable
Mitigation: Proper procedures, safety standards compliance, interlocks, warning labels, emergency shutoff button

Hazard: (E) Loss of external cooling
Category: 3/C – Marginal / Occasional
Mitigation: Software and hardware interlocks, emergency shutoff button

Hazard: (E) Damage by cooling liquid leakage
Category: 2-3/D – Critical-Marginal / Remote
Mitigation: Software and hardware interlocks, emergency shutoff button

7.18 Control Room Components

Hazard: (P/E) Accident during transportation, installation, or removal
Category: 2-4/D – Critical-Negligible / Remote
Mitigation: Proper handling and installation procedures, safety standards compliance

8 Conclusion

All of the risk factors are acceptable, although many will require consultation with the LBT Observatory prior to delivery of the instrument to the mountain.