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EINSTEIN TELESCOPE

ETO Project Office – Risk Management

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The chronology of Risk Assessment within the Project Lifecycle

1- **The concept is defined** (Project Goal …) : Before starting “Any Design” a set of requirements that the final product must meet (Science objective, Technical performance , Budget constraints …)

2- Mostly **Functional and Technical Requirements** are defined or starting to be defined
A first Risk Assessment is conducted (technical, financial, scheduling risks …)

3- **Design & Development** : preliminary and (detailed) designs based on requirements are created .
Second Risk study is conducted to ensure the design is robust before moving forward.

4- **Verification & Validation** : to ensure each system meets its design specifications and to confirms the telescope meets scientific goals
A parallel Risk assessment is done before, during, and after testing to identify gaps

5- **Construction & Implementation** : Finalize the design and build the telescope
A parallel Risk Assessment is usually done only to ensure safety, reliability, and cost control.

6- **Operation & Maintenance** : Quick regular monitoring, updates, and risk assessments to prevent failures over the telescope’s lifetime.

7- **Decommissioning** : At the end of its operational life, the telescope is safely dismantled or upgraded

Example : Vacuum Pipes

1- **The purpose is defined**

- Reduce air molecules interfering with laser beams
- Minimize thermal fluctuations
- Prevent light scattering & diffraction
- Improve sensitivity to gravitational Waves

Example : Vacuum Pipes

2- Mostly **Functional and Technical Requirements** are defined or starting to be defined

Here's an example of maximum 2 requirements of each type:

Functional Requirements :

FR-001: Vacuum environment for interferometer (laser) :
The system shall maintain an ultra-high vacuum (UHV) environment within the interferometer arms to minimize air molecule interference with laser beams.

FR-002: Reduction of Light Scattering :
The system shall incorporate baffles and optical shields to reduce stray light reflections that could degrade measurement precision.

Performance Requirements :

PR-001: Vacuum pressure level :
The vacuum system shall achieve a pressure of $\leq 10^{-9}$ mbar to minimize residual gas interactions .

PR-002: Material outgassing control:
All vacuum tube materials shall have a low outgassing rate, ensuring long-term stability of the vacuum conditions.

Operational Requirements :

OR-001: Pumping system capability:
The vacuum system shall include turbomolecular, ion, and cryogenic pumps to establish and maintain UHV conditions.

Example : Vacuum Pipes

2- A first Risk Assessment is conducted (technical, financial, scheduling risks …)

Here's an example:

R.VC.Tc-001 : Vacuum leak:

Small leaks in the vacuum pipes could gradually degrade vacuum conditions, allowing air molecules to interfere with laser beams

Impact:
Increased noise, reduced sensitivity of the telescope, and additional maintenance costs.

Mitigation :

- Use high-quality welded joints and seals.
- Perform regular leak tests.

R.VC.Tc-002 : Light scattering from baffles:

Baffles inside the vacuum system might reflect stray light rather than absorbing it.

Impact:
Additional noise in the laser signal, reducing sensitivity.

Mitigation :

- Coat baffles with highly absorptive materials like black silicon.
- Optimize baffle positioning in design simulations.

R.VC.Tc-003 : Vacuum Pump failure:

Mechanical failure in turbomolecular or ion pumps

Impact:
Loss of vacuum, requiring emergency shutdown and repairs of the vacuum pump/ station

Mitigation :

- Install redundant pumping systems.
- Schedule preventive maintenance and remote monitoring.

(1st PO) Risk Campaign Overview

Risk Registers for Groups:

- Interferometer Group: **Done**
- Active Noise Mitigation (ANM) Group: **Done**
- Vacuum & Cryogenics Group: **Done**
- Optics Group: **Done**
- Engineering Department: **Done**
- Suspension Group: **To be planned – Started Technological Risks**
- ETO/ ETC : **Ongoing (ETC)**
- SCB
- OSB

Output

- At the beginning, it was difficult to convince people. However, over time, it became easier as the Risk Culture took hold for at least 60% of those who participated in the campaign.

- Approximately 40% or fewer were not actively contributing. This is not an easy challenge because we are involving key individuals (chairs only), and ideally, all of them should participate to ensure that all subsystems are well covered.

- After the effort we've done together (us and the participants) some groups are now almost autonomous; they have understood the exercise well and, with a "normal" level of support from a Risk Manager, they can identify, assess, and suggest risk mitigation measures.

- Other groups, however, require more assistance

Communication

- Sharing the risk register on SharePoint ? We need to agree on how we share and what we share?
- If possible taking some actions on implementing a mitigation
- Doing presentation on the status of risk analysis and its importance for a bigger audience to raise the culture of risks ?!
- (Preparing a report explaining the risk assessment we've done
- RMP)
- MBSE or Jama

Thank you!

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