Modelling for a Telescope Optical Instrument

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The Telescope

- One of the first giant telescopes
- Under construction in Chile
- Visible and infrared light observations
- Larger primary mirror
- Increased observability

https://www.cfa.harvard.edu/facilities-technology/telescopes-instruments/giant-magellan-telescope

The Telescope

The Giant Magellan Telescope is the work of an international consortium of 14 leading research institutions: Australia, Brazil, Chile, Israel, South Korea, Taiwan, United States

https://giantmagellan.org/

The MANIFEST Instrument

- Fiber Optic Positioner
- In the conceptual design phase
- Increased GMT Observing Capacity
- Simultaneous use of multiple instruments
- Use of gravity-invariant spectrographs
- Increased field of view of instruments
- Facilitate the addition of new science tool future

https://aao.org.au/projects/manifest-fibre-positioning-system-for-the-gmt/

Safety Analysis on GMT

- Every GMT instrument will undergo FMECA
- STPA as a proof of concept:
  - Application in a small and simple subsystem selected by management
  - Focus on human agents' impact on the subsystem
  - Controlled Process is the observation done by the instruments
  - Complement FMECA results

Modeling assumptions

- MANIFEST's light-gathering equipment, which is responsible for capturing, treating, and filtering light, is working as expected
- The spectrographs that will receive the light from MANIFEST are working as expected
- MANIFEST is being employed in telescope observations

Definition of the Purpose of the Analysis

- Goals:
  - Ensure the throughput required for the operation of the spectrographs
  - Reduce performance loss on interfaces
  - Prevent harm to telescope staff
  - Prevent damage to equipment
  - Ensure the correct functioning of MANIFEST

Definition of the Purpose of the Analysis

- Losses:
  - L1: Loss of observation
  - L2: Reduced throughput
  - L3: Human injury
  - L4: Damaged equipment

Definition of the Purpose of the Analysis

- System-level Hazards:
  - H1: MANIFEST is unable to collect light [L-1]
  - H2: MANIFEST is damaged [L-1] [L-2] [L-4]
  - H3: Maintenance team members suffer injuries [L-3]
  - H4: MANIFEST is unable to pass on collected light [L-1] [L-2]

Control Structure Modeling

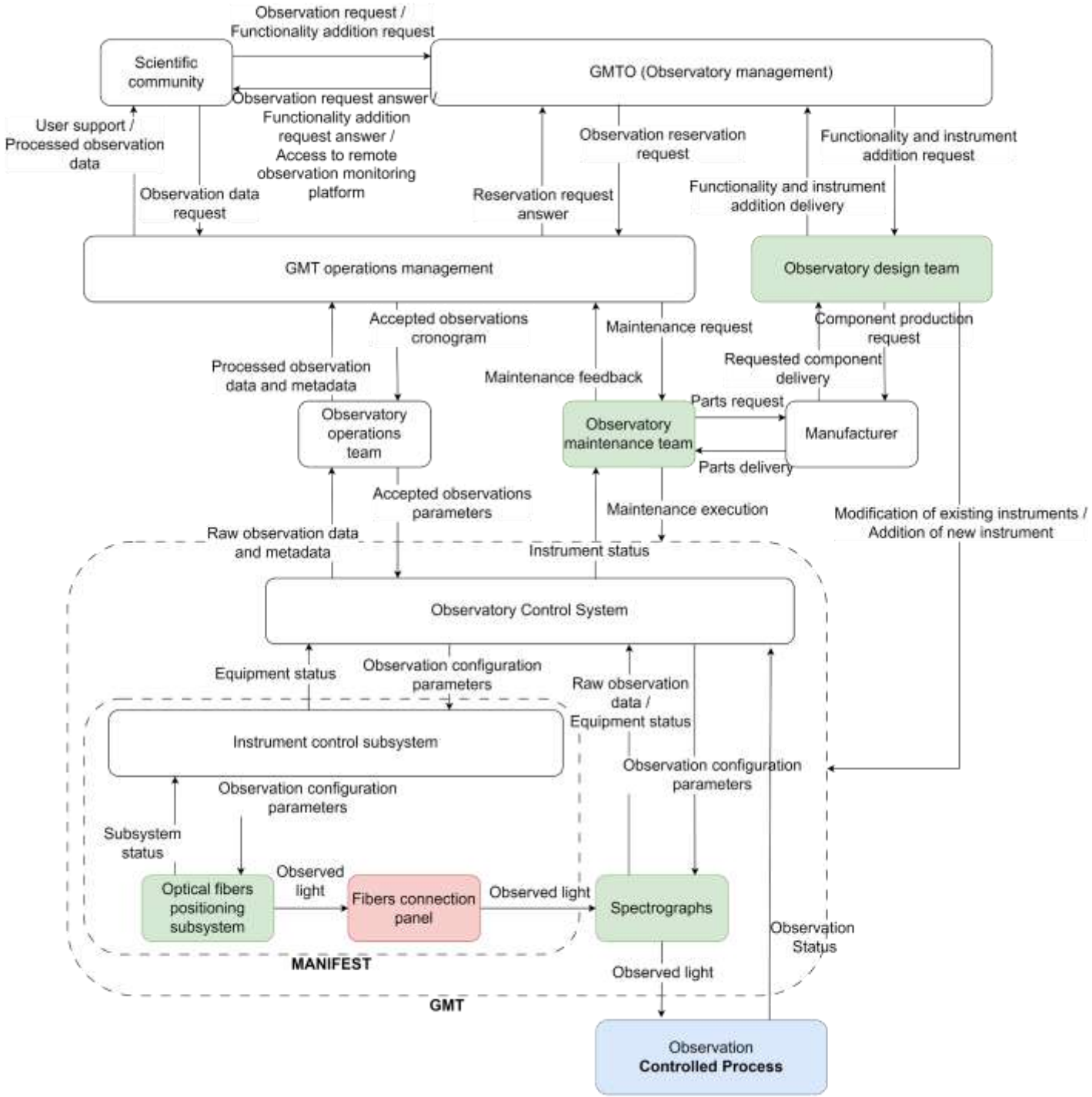
- Creation of a more complete Control Structure
  - GMT administration
  - Scientific community
  - Engineering team
  - Maintenance team
  - Observatory physical structure
  - Software controllers
- Simplification to a more concise structure
  - Focus on the analyzed subsystem
  - Only include elements that interact with analyzed subsystem

1 Structure Modeling

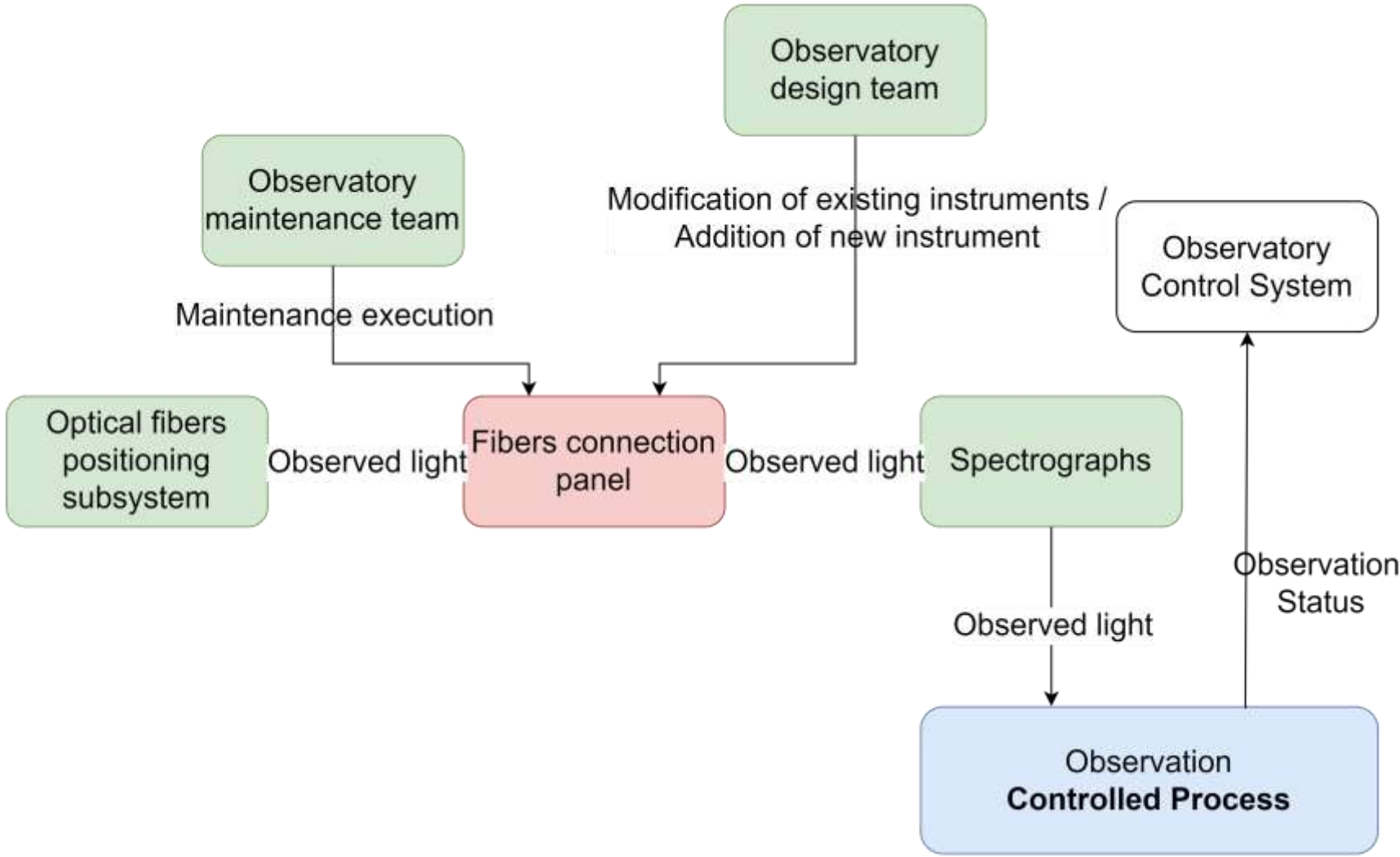
Analyzed Subsystem

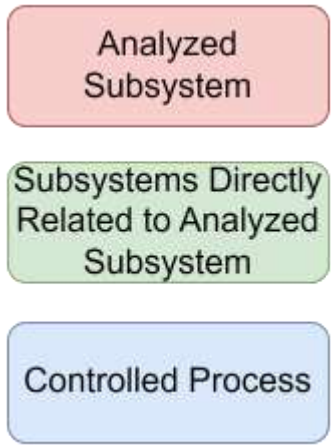
Subsystems Directly Related to Analyzed Subsystem

Controlled Process



Structure Modeling





Identification of Unsafe Control Actions

- 7 identified UCAs
- Examples:
- UCA-1: The observatory's design team provided the insertion of a new instrument incompatible with the existing infrastructure at GMT. [H-4]
- UCA-2: The observatory's design team provided incompatible modification of existing instruments. [H-1][H-2][H-4]
- UCA-3: The observatory's maintenance team carried outperforming maintenance in the incorrect order. [H-3]

Identification of Loss Scenarios

- 10 identified loss scenarios
- Examples:
- LS-6: Observatory design team designs the MANIFEST without enough space on the connection panel of fibers for the installation of optical fibers for planned equipment. [UCA-1]
  - Recommendation: The observatory design team must ensure that the MANIFEST fiber connection has enough space for the interface with the instruments provided by the GMTO.

Identification of Loss Scenarios

- LS-5: The observatory's design team modified MANIFEST by inserting new components that are not compatible with previous components, making the observation process less efficient or unfeasible or damaging the system. [UCA-2]
  - Recommendation: The observatory design team must ensure that modifications provided to components and subsystems are consistent with the previously delivered project.
- LS-1: The observatory's maintenance team carried out the maintenance of components by not following the step by step of the maintenance manual because they do not understand the information contained therein, resulting in parts not correctly fixed which may fall and cause injury to workers. [UCA-3]
  - Recommendation: The manuals provided to the observatory maintenance team must be reviewed to ensure that the necessary information are present clearly and in a language

Conclusion

- Possible complement to current GMT analysis tool (FMECA)
- Inclusion of human agents
  - Identification of hazards during maintenance
  - Identification of hazards during instrument design
- Possibility of expansion of analysis of the analysis on future project phases
  - More in depth analysis of MANIFEST
  - Analysis of other instruments
- Challenging to analyze passive elements with STPA
  - No control action and no feedback

Thanks for the attention!

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