

# Nebula Net Interactive Feed

## (SDS) Software Design Specification

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## Software Design Specification

### 1. Document Summary:

- This document serves as the Software Design Specification (SDS) for the Computer Science 422 Software Methodologies Project 2 assignment Nebula Net Interactive Feed. It functions as the comprehensive design blueprint for the project, encapsulating program requirements, system architecture, detailed module specifications, and documentation revision history. Incorporated within are elaborate diagrams conforming to the Unified Modeling Language, illustrating architectural components and modes. This is an initial draft of this document and will be submitted upon completion and will undergo revisions in response to feedback provided by the instructor.

### 2. SDS Revision History:

Date	Author	Description
<b>Week 0</b>		
15FEB	Willard	SDS Google Doc Setup/Shared
17FEB	Entire	Project Plan Roughly Drafted

	Group	
<b>Week 1</b>		
18FEB	Willard	SDS setup or self-reporting of tasks
20FEB	Willard	Timeline Set up and revised
23FEB	Entire group	Filled out respective modules and added models
24FEB	Willard	Working Initial Submission models added and modified
25FEB	Willard	Working on module edit description form peer input
<b>Week 2</b>		
26FEB	Willard	Finalize SDS for submission and submitted
<b>Week 3</b>		
06MAR	Willard	Edit for functional changes
<b>Week 4</b>		
12MAR	Willard	Finalized for final submission

### 3. System Overview:

- The Nebula Net Interactive Feed hosted website on local servers is a website and supporting software that allows users to view up-to-date JWST photos and the completed mission compiled photos. This is done with two web pages: the home landing page and the mission timeline page. The home landing page will display the last mission photo taken from JWST. This page will have a list of informative information and the current mission this photo is a part of. The second page is a mission timeline that will provide the mission information from the NASA JWST website. Here the user will be able to interact, download, and view photos from the JWST through a limited user interface so all interactions are click-based and not text-based. The website as a whole will be run on a React software framework to allow flexibility in hosting on different devices. Likewise, the set of Processing modules will be running on the Python scripting language as well as the testing module.

### 4. Software Architecture:

- The Nebula Net Interactive Feed is a web-based platform hosted on local servers, facilitating the viewing of up-to-date James Webb Space Telescope (JWST) photos and compiled mission images. The system comprises of two primary web pages: a landing

page displaying the latest mission photo captured by the JWST, and a mission timeline page providing comprehensive mission information sourced from the NASA JWST website. User interactions, such as photo viewing and download capabilities, are facilitated through a limited user interface optimized for click-based interactions.

## 4.1. NebulaNet Component Architecture

### 4.1.1. Space User Interface (SUI) (The displayed website):

Provides and displays photographic, mission, and informative data from the official James Webb Space Telescope (JWST) Database and website hosted by the National Aeronautics and Space Administration (NASA). This allows users to view the mission photo of the day that is part of a larger mission that is used to create the large and compiled beautiful photo that most are familiar with. The website will display only the current mission photo set and the mission timeline with the compiled photos from each completed mission.

### 4.1.2. Photo and Metadata Coalescence - Fits→Notation+PNG (PMC-FNG)

The PMC-FNG module plays a crucial role in enhancing user accessibility to astronomical imagery captured by the JWST. Its primary function is to convert Flexible Image Transport System (FITS) files, the standard format for astronomical data, into Portable Network Graphics (PNG) images, which are more readily viewable by users. Leveraging libraries such as astropy, numpy, and matplotlib, PMC-FNG processes FITS files to render detailed PNG images, enabling users to visualize celestial data in grayscale or color format. Additionally, PMC-FNG stores metadata for each PNG image within text files, ensuring that relevant contextual information accompanies the visual representation. This module interfaces with the Space User Interface (SUI) through a directory to encourage loose coupling and replication for other, providing PNG images and metadata derived from JWST observational data fetched from the MAST database.

### 4.1.3. Mission Information Gatherer (MIG)

The MIG module serves as the backbone for retrieving mission-critical data from the James Webb Space Telescope (JWST) website, ensuring users have access to up-to-date mission information. Its primary function is to gather observing schedules data and organize it into a structured format for seamless integration into the Nebula Net platform. By efficiently collecting and organizing

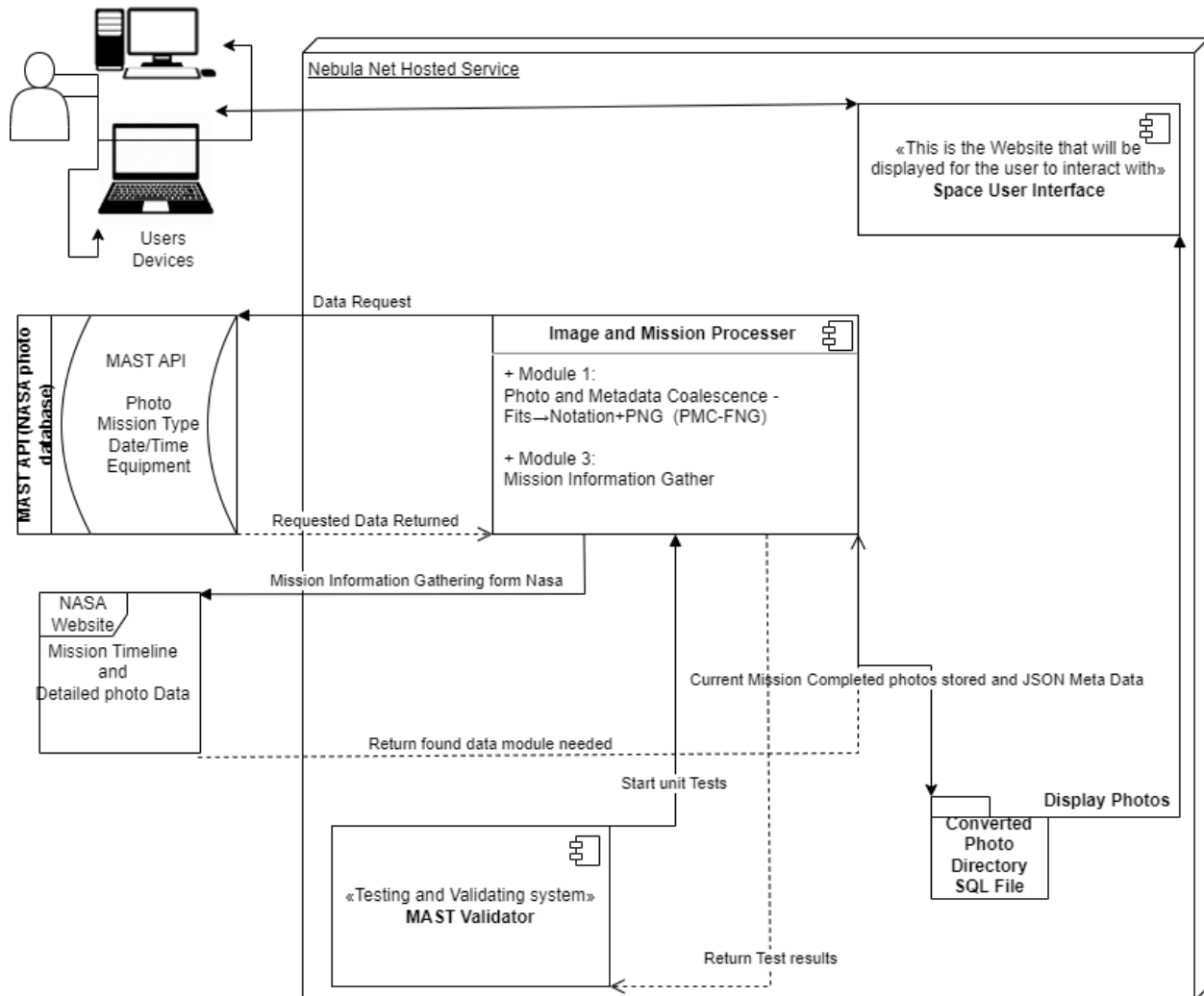
mission data, MIG enables users, including researchers and enthusiasts, to stay informed about upcoming missions and observations. Leveraging web scraping techniques, MIG extracts data from the JWST website's observing schedules, converting it into JSON format for efficient storage and processing. This module interfaces directly with the PMC-FNG and in the static version SUI, supplying mission data for display on the website's landing page and mission timeline.

#### 4.1.4. MAST Validator (MASTv):

The MASTv module serves as a critical component in ensuring the integrity and functionality of the Nebula Net Interactive Feed system. Its primary role is to validate the functionality of key modules, including the Mission Information Gatherer (MIG) and Photo and Metadata Coalescence - Fits→Notation+PNG (PMC-FNG), by conducting comprehensive unit tests. MASTv verifies the proper functioning of the MAST API connection and the accessibility of the JWST observation website, detecting any potential issues or changes that may impact the system's operation. By running defined unit test cases, MASTv assesses the functionality of each module, identifying bugs, dependencies, or implementation changes that require attention. This module operates during the initial setup or reset of the website, ensuring that the back-end Python programs function as intended and providing early detection of any discrepancies or inconsistencies. Through its rigorous testing procedures, MASTv contributes to the reliability and stability of the Nebula Net platform, ensuring a seamless user experience and facilitating timely resolution of any detected issues.



## Nebula Net Component Diagram






This is a UML Diagram Showing the components and their interaction

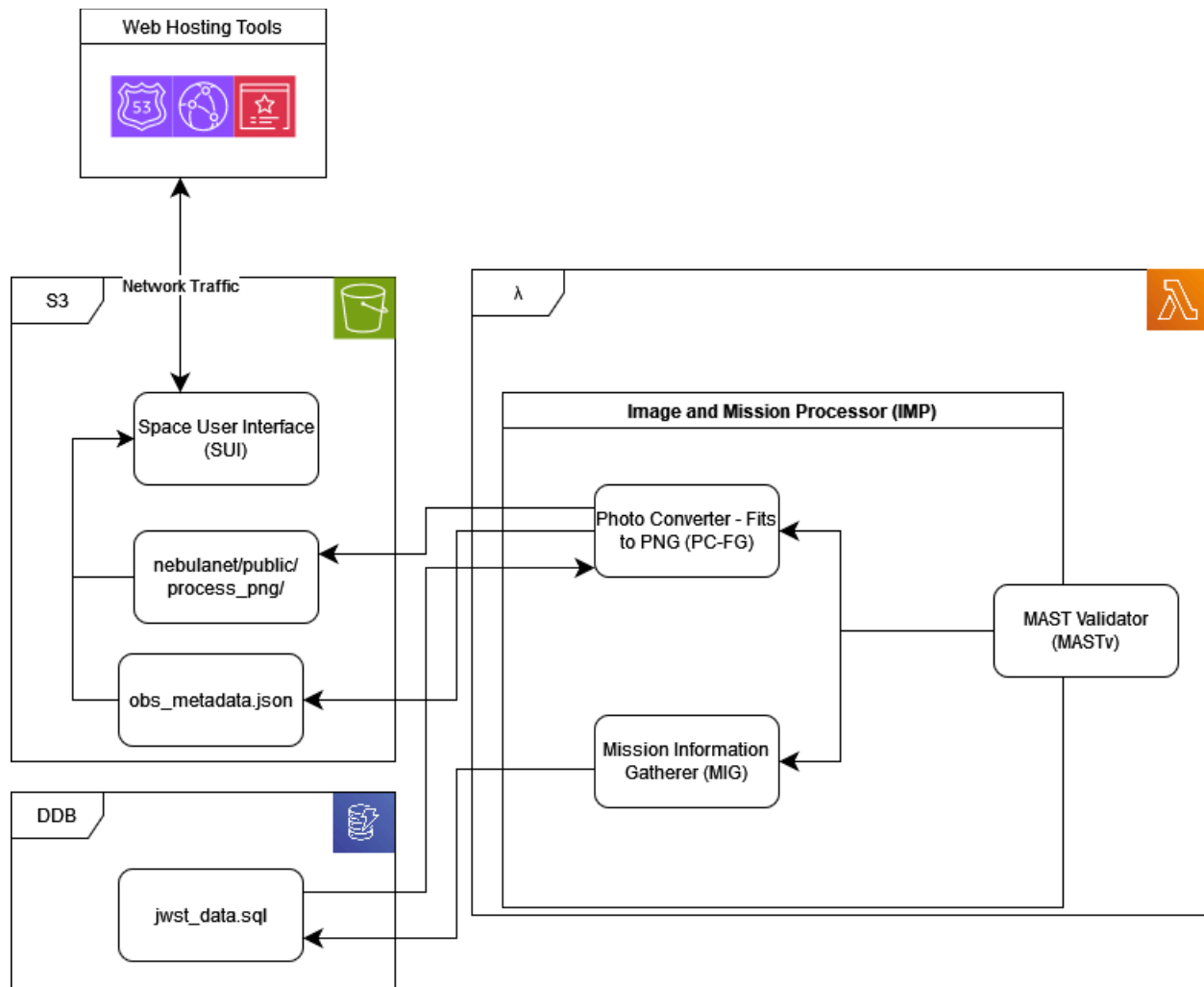


### 4.1.5. Web Hosting Architecture

#### 4.1.5.1. AWS Components

- 
**Route53:** A Domain Name System (DSN) webservice offered by AWS. Used to register the domain name for the website, as well as connect incoming user requests to the respective Availability Zone the site is hosted at.
- 
**CloudFront:** Amazon Web Services Content Delivery Network. Essentially is a distributed network of servers amongst the different availability zones. Optimizes delivery of website traffic and supports use of SSL certificates.

-  **Certificate Manager:** Used to register and manage SSL/TLS certificates in other AWS services.
-  **Simple Storage Service (S3):** The standard cloud storage service offered by AWS. Used to store React website packages and host the static website itself.
-  **Identity Access Management:** Manage user access and role permissions within AWS. For the NebulaNet project, this service was required to create roles for Lambda functions that allowed them to directly access S3 files/objects.
-  **Lambda:** A serverless compute service that allows programs to be run without dedicated hardware or server environments. For NebulaNet this service is used to run the Mission Information Gatherer and Image and Mission processor modules. Resulting data is then gathered and returned to files stored in S3, or eventually a DynamoDB.
-  **DynamoDB:** A serverless NoSQL database service offered by AWS. Similar to S3, costs only accrue based on the amount of data stored and read/write accesses made.



**Web Hosting Architecture Diagram**

#### 4.1.5.2 AWS Issues/Future Plans

During development of the NebulaNet project, it was brought to the attention of the group that there was a key design flaw with the original implementation. After the first week of development, it was decided that the team would change over from using the EC2 service to instead follow a serverless architecture. This change was made to keep costs within a reasonable amount, as running serverless functions and code is significantly cheaper than renting out a portion of an EC2 server. However, during the process of making this change, it was discovered that SQL databases could neither be loaded or accessed from within S3. This is due to SQLite being a classic serverless architecture as it runs within the same process and address space as the function that's using it. Instead what the team requires and what DynamoDB is classified as is a Neo-Serverless database. A Neo-Serverless database runs in a separate namespace or machine, but is still accessible through a hosting provider (such as AWS). Alternatives were researched, however it was concluded that the best approach forward would be to



refactor our code to switch over from SQLite to DynamoDB. In the interest of time, and to ensure the original implementation using SQLite can run on IX-Dev, this task will be postponed to a future implementation of the project. The current implementation of the AWS site requires running the functions on a local machine and then updating the files hosted on S3 manually. The final implementation of the project will have a refactored codebase that supports using DynamoDB, and will also utilize AWS EventBridge to schedule and co-ordinate Lambda functions and filling/updating the DynamoDB and S3 website.

## 5. Software Modules:

### 5.1. Space User Interface (SUI) Module:

#### 5.1.1. Role and primary function:

- **Role:**

The Space User Interface (SUI) Module plays a pivotal role in shaping the website's user experience by implementing the landing page and key functionalities. Its primary role is to design and structure the landing page, including the header section with essential links to other pages such as Calendar, About, and Sources. Additionally, it orchestrates the display of the daily James Webb telescope photo and previews of pictures taken within the previous three days, providing users with easy access to relevant content and navigation options.

- **Function:**

The Space User Interface (SUI) Module serves as the visual representation of the website's components and modules, ensuring an intuitive and seamless user experience. Leveraging REACT, it adopts a modular approach to website development, enabling the creation of subpages and a mobile version adaptable to various screen sizes. By incorporating responsive design principles, it enhances accessibility and usability across different devices, catering to the diverse needs of users.

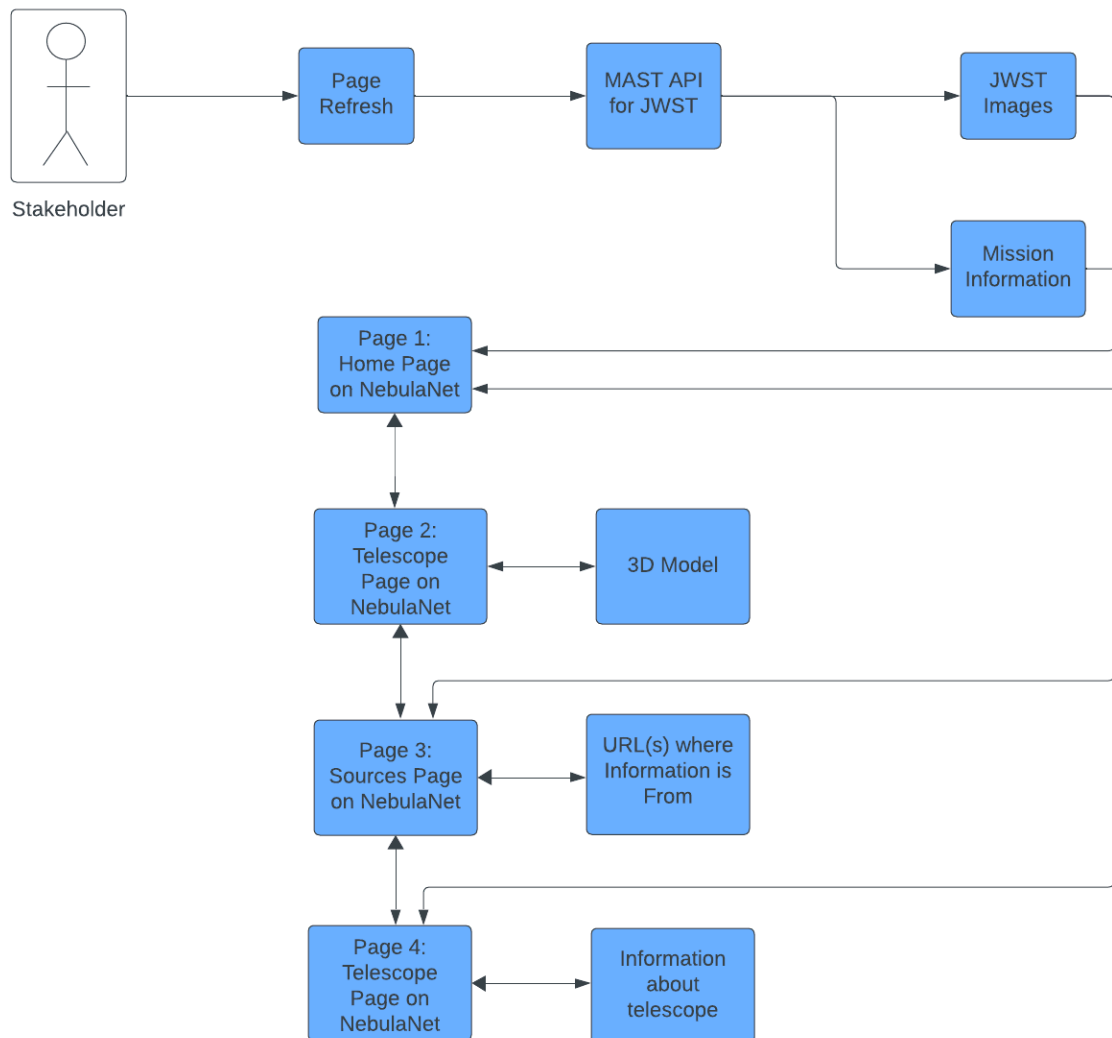
#### 5.1.2. Components:

- **Role:** The components directory contains all the javascript and corresponding css files that create each object used within the website.
- **Function:** This allows for easy creation of additional pages throughout the website as predefined components can be called to be placed wherever they are needed. This promotes modularity and ensures strong cohesion within the entire SUI.

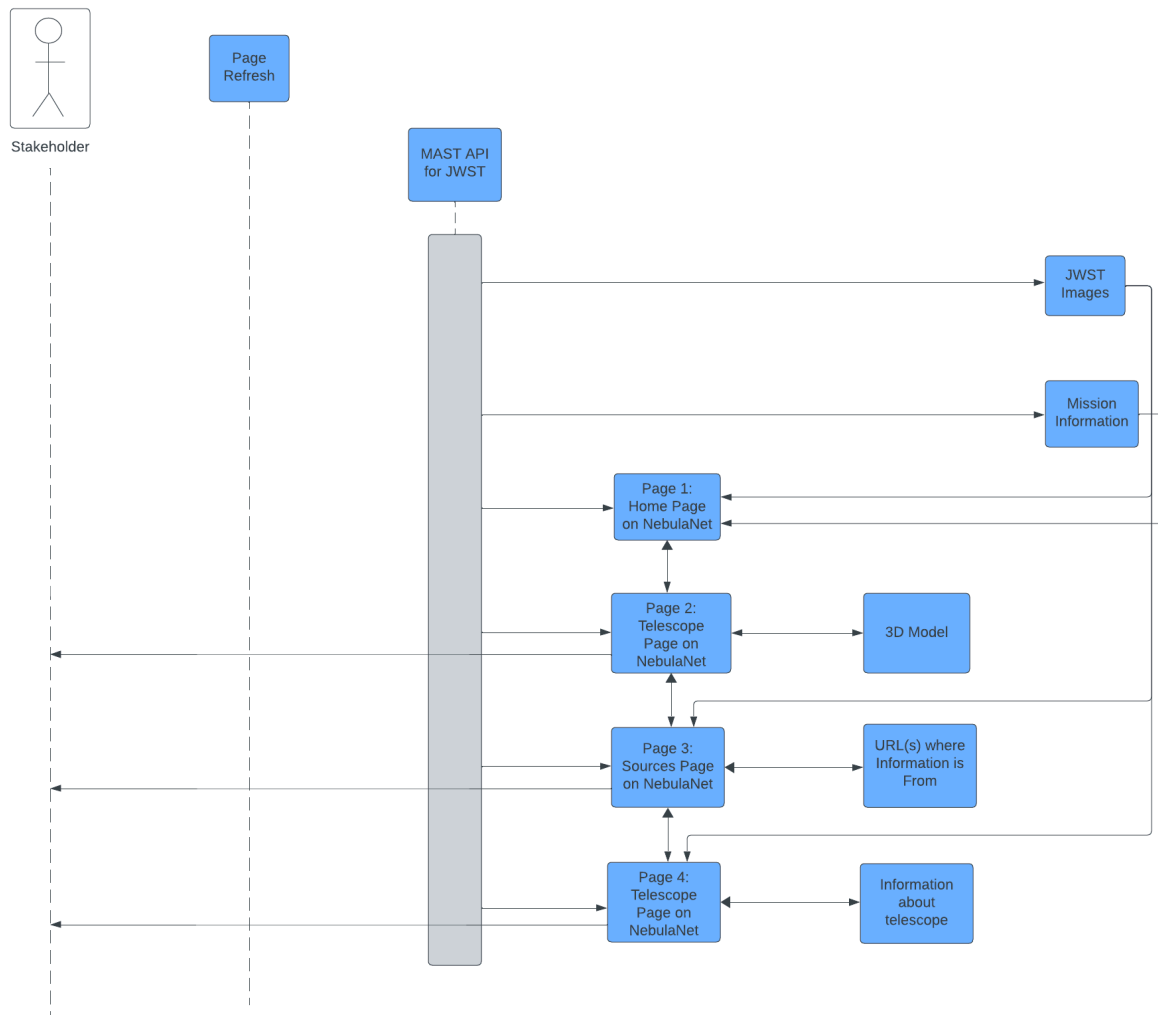
### 5.1.3. Interface to other modules:

The app.js web page serves as the cornerstone for interconnecting all modules within the software system, acting as the primary gateway for user interaction. It orchestrates the retrieval and display of backend data in a visually appealing format, ensuring a seamless and aesthetically pleasing user experience. Additionally, embedded links to other pages within the website are integrated into the landing page, facilitating effortless navigation between modules and web pages.

### 5.1.4. Static model:



### 5.1.5. Dynamic model:



### 5.1.6. Design rationale:

The design rationale for the landing page prioritizes the presentation of the daily observation from the James Webb telescope as the central focus upon user entry, aligning with the site's primary purpose. Following this, a descriptive section is situated below, featuring details such as the object's name, date of capture, and a concise narrative on the photographic process and associated mission. This sequential layout aims to facilitate user engagement by allowing them to appreciate the displayed photo before delving into its contextual background. As users navigate down the page, a condensed preview of the previous day's photos is provided alongside a button leading to the mission timeline webpage

which will display a timeline of all missions that the JWST has completed since launch.

## 5.2. Photo and Metadata Coalescence - Fits→Notation+PNG (PMC-FNG):

### 5.2.1. Role and primary function:

#### **Role:**

The Photo and Metadata Coalescence - Fits→Notation+PNG (PMC-FNG) module is designed to facilitate the conversion of Flexible Image Transport System (FITS) files, the standard format for astronomical data, into PNG (Portable Network Graphics) image formats. It leverages the *astropy* library for FITS file processing, then uses *numpy* library to process the FITS file and return the scaled image data. The *matplotlib* library is used to translate the FITS data into 2D arrays representing pixel shading values. These values are then rendered into detailed images, enabling the visualization of celestial data in grayscale or color PNG format.

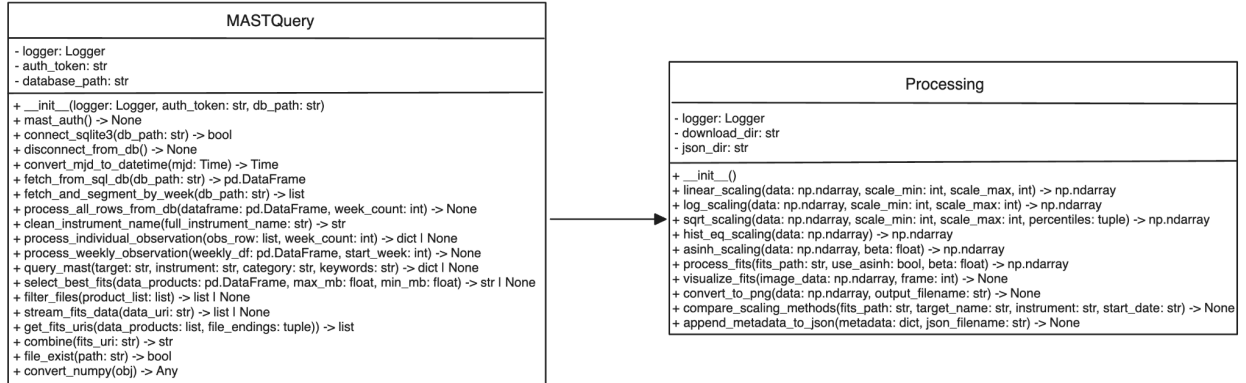
#### **Function:**

Beyond converting FITS to PNG, the PMC-FNG module stores metadata for each corresponding PNG image within text files. This approach ensures that each visual representation is accompanied by relevant contextual information, which enhances the understanding and utility of the images. By parsing FITS field for both imagery and metadata.

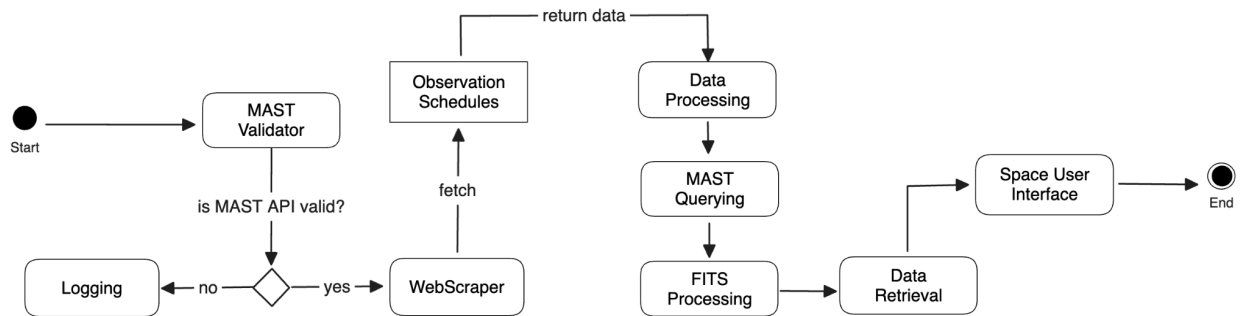
### 5.2.2. Interface to other modules:

This module interacts with the Space User Interface (SUI) with PNG images and their metadata, derived from the current mission's observational data fetched from the MAST database. This interface supports the SUI's role in displaying mission-critical photos and providing user engagement with the data.

### 5.2.3. Static model (Class Diagram):



### 5.2.4. Dynamic model (Activity Diagram):



### 5.2.5. Design rationale:

The rationale behind the design of the Photo Converter - FITS to PNG (PMC-FNG) module stems from the inherent challenge of viewing .fits files without specialized software, rendering them inaccessible to the average user. Thus, the module aims to address this limitation by facilitating the conversion of .fits images into viewable photo files accessible over a network for the Space User Interface (SUI). The design choices are constrained by the nature of the SUI being a website, necessitating adherence to the preexisting network and MAST API systems prescribed by NASA.

Python was selected as the programming language due to its extensive support for scientific computer and data visualization. Specifically, the *astropy* library allows for robust handling of FITS files that enables precise reading and processing of astronomical data. This library is essential for extracting the detailed, multidimensional arrays that FITS files often contain, which provides raw data that's necessary for image conversion.

Furthermore, *numpy* enhances the modules capabilities by offering high-performance numerical computations. This is particularly crucial for processing datasets typical in astronomical observations, which allow for efficient manipulation of image data arrays. Numpy's array operations are crucial for transforming pixel values into a format suitable for visualization.

For the actual conversion to PNG format, *matplotlib* is utilized for its extensive plotting functionalities and support for various output formats. It translates the numerical data processed by *numpy* into gradations of shading, which renders detailed grayscale or color visual representations.

Post conversion, to optimize storage, the original FITS files are discarded, acknowledging their large size and the premium on storage space. Concurrently, metadata for each PNG image is saved into a text file, ensuring that essential information is retained and easily accessible. This approach not only makes astronomical data more approachable but also manages storage efficiently, maintaining the system's responsiveness and relevance. The module's strategic focus on the current mission's photo set, coupled with periodic purging of the photo directory, further ensures that only pertinent and timely data is available, enhancing the GUI's operational efficiency and user experience.

### 5.3. Mission Information Gatherer (MIG) Module:

#### 5.3.1. Role and primary function:

- **Role:**

The Mission Information Gatherer (MIG) Module is entrusted with the responsibility of managing and retrieving requests from the James Webb Space Telescope website, with a specific focus on gathering observing schedules data. Its primary role is to extract data from the website's observing schedules and organize it into a structured list format. Subsequently, this organized data is stored in a JSON file for efficient storage and further processing.

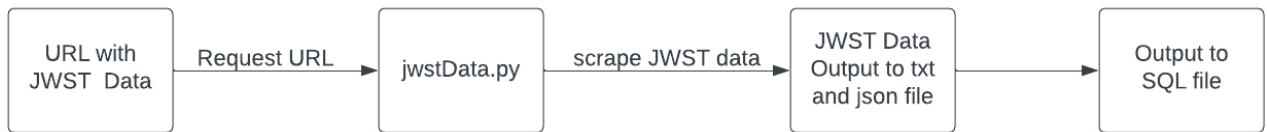
- **Function:**

The Mission Information Gatherer (MIG) Module assumes a pivotal role in facilitating access to mission-related data sourced from the James Webb Space Telescope website. By efficiently collecting and organizing observing schedules data, it enables researchers and enthusiasts to remain informed about upcoming missions and observations. Additionally, by providing the data in a structured JSON format, it facilitates seamless integration with other systems or applications for analysis and utilization.

### 5.3.2. Interface to other modules:

The design rationale for the web scraper is centered on retrieving current data from the observing schedule of the James Webb Space Telescope website. This observing schedule data serves as valuable input for various modules, including the landing page and information about previous telescope images.

### 5.3.3. Static model:



### 5.3.4. Dynamic mode:



### 5.3.5. Design rationale:

The design rationale for the web scraper emphasizes the extraction of all of the data from the observing schedule of the James Webb Space Telescope website. Since each URL is needed, BeautifulSoup and the requests library are used to find the URLs with the 'a' tag and then limit the scope to finding any href link that ends in 'txt'. Once those are retrieved, there is a second request that allows the retrieval of the data, converting it into a .text format for subsequent processing. Once retrieved, the data is appended to a list and returned. A

secondary function is employed to write this data to a Txt file, while a tertiary function converts it into a Python list for further manipulation and analysis. Two more Python files are created, one for parsing the txt file and extracting it to JSON format and the other for reading the JSON file and extracting it to SQLite. This approach ensures efficient data extraction and processing, facilitating seamless integration with other modules within the software system.

## 5.4. MAST Validator (MASTv)Module:

### 5.4.1. Role and primary function:

- **Role:**

The MAST Validator Module acts as a verification mechanism for both the Mission Information Gatherer (MIG) and Photo to Converter - Fst to PNG (FC-PG) modules to determine if the MAST API is functioning as intended for the current expected implementation and to verify that the JWST observation website is online. It accomplishes this by trying several different API requests by importing the FC-PG classes and running defined unit test cases. There is also a separate test to verify that the JWST observation website is online just before the MIG module runs.

- **Function:**

MASTv is a part of the system admin tools and runs during initial website setup or reset. It's intended to verify that the scheduled back-end Python programs work, but also to detect any changes that may have occurred resulting in bugs and issues, whether that be changes to the code implementation or the website/python library dependencies breaking or changing significantly in how they function.

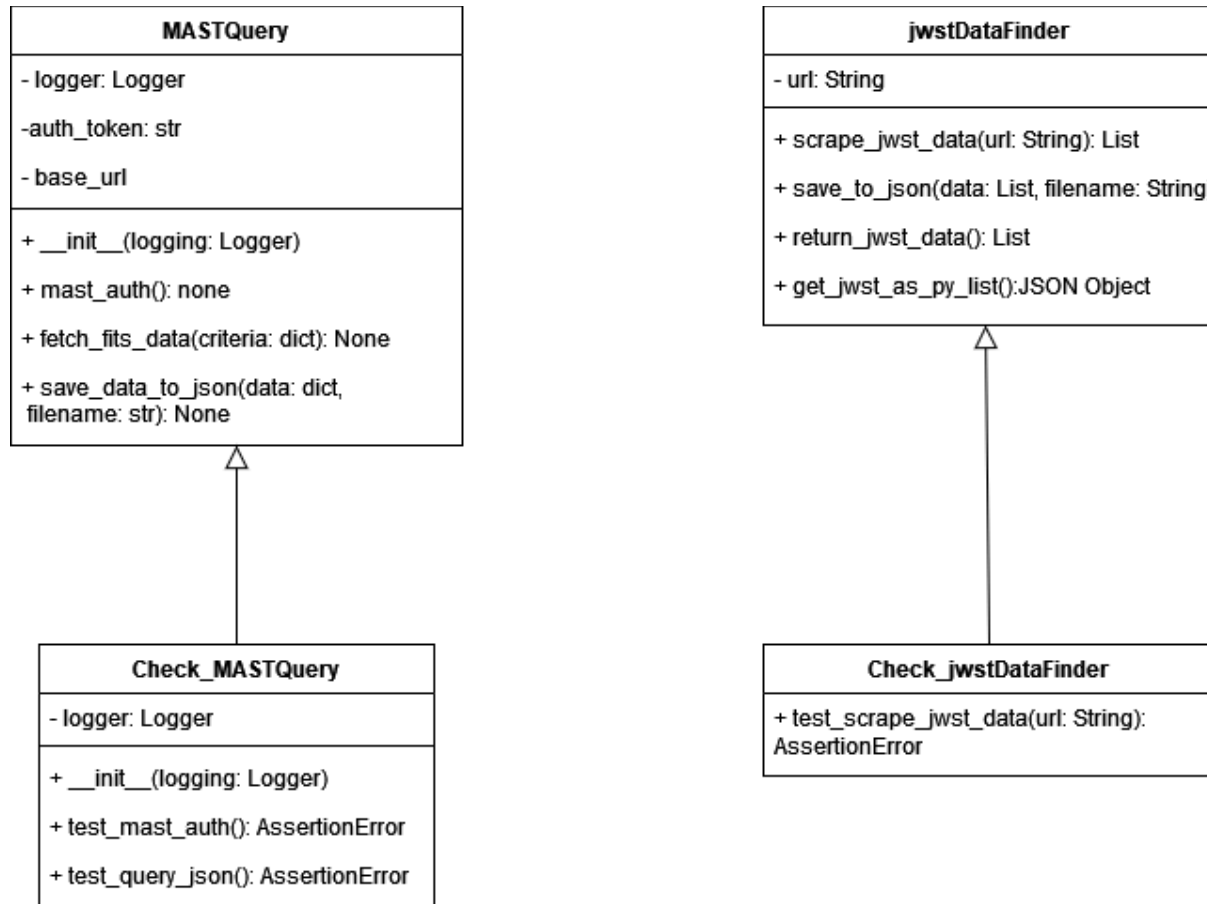
### 5.4.2. Interface to other modules:

The MAST Validator directly imports the PC-FG Module Python classes and runs several unit tests using the imported functions. There is no direct communication with the other modules, as the MAST Validator module only runs during the initial website setup or any reset processes.

### 5.4.3. Static model:

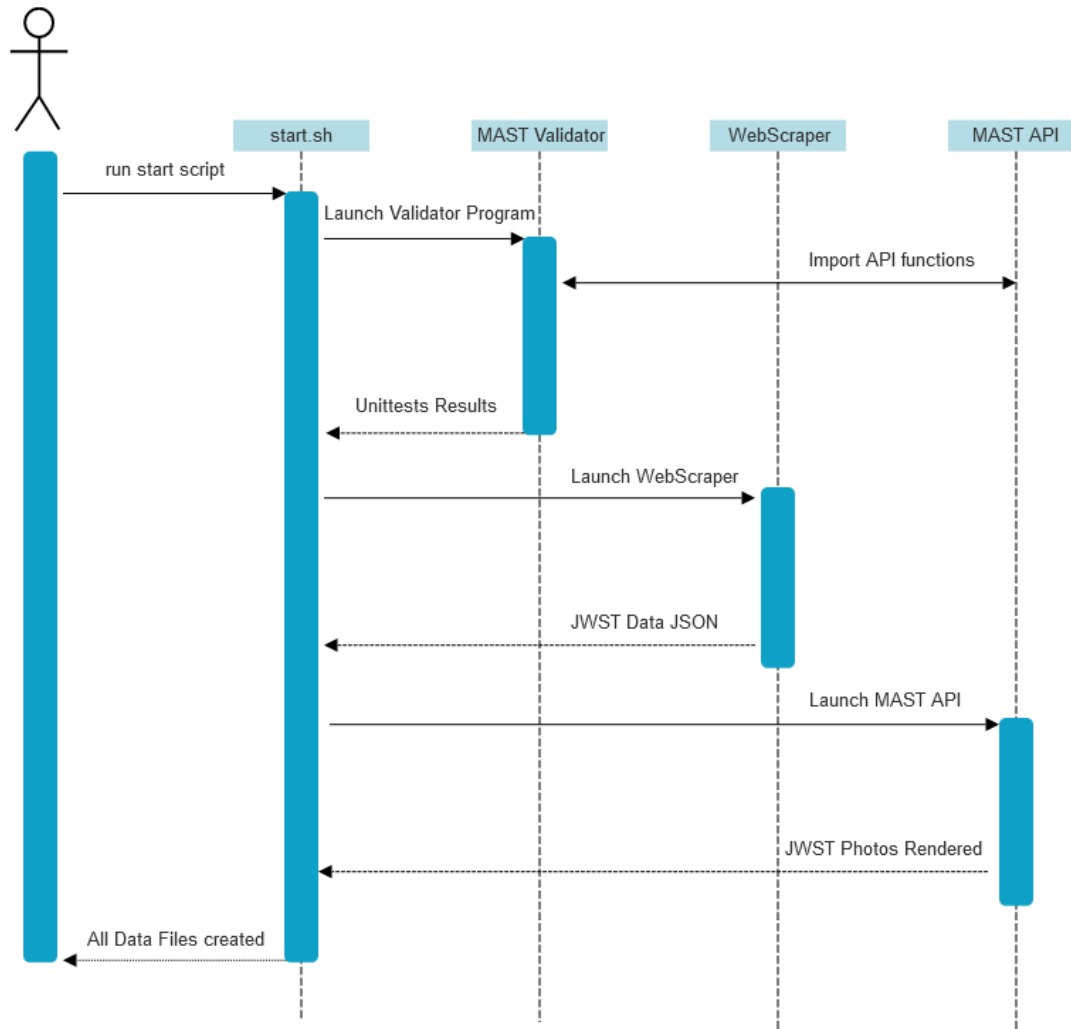
- **UML Class Diagram for MAST Validator**





#### 5.4.4. Dynamic model (Sequence Diagram):

##### - UML Sequence Diagram for Start Shell Script



### 5.5. Design rationale:

Choosing Nose extends the default unit testing functions that Python provides. A majority of the group has prior experience with using the testing library from previous computer science courses. The Library also supports easy shell scripting and coordination if there are multiple different tests to run. Because the PC-FG & MIG modules are written in Python, MASTv should also be written in the same language to avoid programming language incompatibilities. The reason for the modules' existence is to verify that the functionality of the current module works as intended, help debug issues during the implementation step of the software design lifecycle process, and to detect any issues with dependencies that the project relies on such as libraries or websites/API's.

## 6. References:

- Faulk, Stuart. (2011-2024). CIS 422 SDS Template. Downloaded from <https://classes.cs.uoregon.edu/24W/cs422/Handouts/Template-SDS.pdf>
- Hornof, Anthony. (2024). CS 422 Project 2 Resources download form <https://classes.cs.uoregon.edu/24W/cs422/P2/>
- IEEE Std 1016-2009. (2009). IEEE Standard for Information Technology—Systems Design—
- Software Design Descriptions. <https://ieeexplore.ieee.org/document/5167255>
- Parnas, D. L. (1972). On the criteria to be used in decomposing systems into modules. Commun. ACM, 15(12), 1053-1058.
- Sommerville, Ian. *Software Engineering*. Pearson Higher Ed, 2011.

## 7. Acknowledgments:

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