PUCIT
Punjab University College of Information Technology

First Deliverable

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1 Introduction

The role of glaciers in climate and water, especially in the Himalaya-Karakoram (HK) area, is critical given that HK has some of planet's largest and growing glaciers. Offshore glaciers are imperative sources of fresh water, food, and hydropower for millions of inhabitants dwelling downstream from these glaciers. However, conventional glacier mapping techniques are tedious and they involve a lot of manual work, in addition, they give imprecise results because of the confusion that usually comes with the similarity of spectral properties between both supraglacial debris (SGD) and the periglacial debris (PGD).

In order to meet these issues, **Ice Age,** our project, conceptualizes the automated system to detect and map debris containing glaciers. Ice Age uses deep learning and multisource remote sensing data and to delineate accurate glacier boundary, fully connected SGDNet is proposed and used.

Indeed, there is much that can be gained from this automated detection system. From the highly specific and accurate depiction of debris covered glaciers, Ice Age can greatly benefit and improve learning about the movement of glaciers and add value to the overall cause of combating and addressing climate change. Glacier maps will also assist with planning and risk mitigation in regard to other possible natural disasters like glacial flood or landslides and thus safeguard people and facilities within endangered areas. Further enhanced glacier observation will facilitate better water resources management, availability and usage of fresh water and in overall efficiency of hydro power plants in HK region.

This deliverable must contain following artifacts:

a. Project Feasibility
b. Project Scope
c. Project Costing
d. Critical Path Method Analysis (CPM Analysis)
e. Gantt Chart
f. Introduction to team members
g. Tools and Technologies
h. Vision Document
i. Risk List

1.1 Project/Product Feasibility Report

It is always important to first determine a project's viability in any given environment at the beginning of a planned project. Feasibility assesses the mechanical availability of the required data for the project to develop, including staffs, expertise, time, and equipment.

The purpose of such an assessment is valuable as it helps evaluate the feasibility of the implementation of a software system in an organization based on its identified advantages. Feasibility appraisal is an iterative process, and the evaluation continues even at later stages of the project, in order to prevent the achievement of objectives from diverging from the organisational and resource capacity.

There are many types of feasibilities:

- Technical
- Operational
- Economic
- Schedule
- Specification
- Information
- Motivational
- Legal and Ethical

1.1.1 Technical Feasibility

Technical Feasibility refers to fundamental decisions that require answering questions related to a project's development possibilities. It is based on evaluating potential theoretical and technological limitations which may detrimental to the project. This stage is of utmost importance since it defines the feasibility of the suggested system or solution. Key considerations include:

System Development Potential: This aspect considers whether the proposed system is implementable based on the current technological as well as theoretical standards of possibilities. It evaluates on how viable it is to set up the intended functionalities and features using the available technologies.

Theory and Technology Application Limits: These are some of the fundamental factors that project planners need to consider for them to understand the appropriate theory and technology that should be applied on any development. It involves outlining and studying the processes, methods, algorithms, and ways of computation in order to pursue the goals set in the course of a project.

Availability of Technical Expertise: Another vital consideration in the decision-making process is whether the project team has skills in the technical field to implement the development. They should be conversant with the sort of programming languages, frameworks, and tools that would be useful for developing the system and installing it properly.

In the case of the **"Ice Age"** automated debris-covered glacier detection system, the technical feasibility is supported by:

Use of Advanced Deep Learning Technologies: The elaboration of deep neural networks including SGDNet in the context of this research proves the capacity to manage and analyse multisource remote sensing data for accurate glacier mapping using TensorFlow and Keras in Python environment.

Python-Based Backend and JavaScript Framework for Frontend: For backend operations, Python language will be used, and for the frontend, Owl Framework written in JavaScript (e. g. Functional requirements (Lookup, entry, User registration, User login, Home page, Image upload and Categorization, Result display) provide a strong structure and proper data management & handling along with the interactivity with the users.

Integration of Multispectral and Multiresolution Remote Sensing Data: An integration of various data sources from Sentinel-2 MSI, Sentinel 1 SAR, Landsat 8 Thermal Infrared as well as ALOS DEM demonstrates the effectiveness of the system, which is able to organize and process plural geospatial details for exhaustive glacier examination.

Optimization and Performance Evaluation: The use of efficient and standard methods like standardization of the data, data augmentation, and adaptive learning rate optimization with the Adam optimizer provide a proper model training it also upheld to proper performance tests using different standard metrics.

Visualization and Reporting Capabilities: The usage of Matplotlib and pandas for plotting training metrics and generating reports would help the stakeholders analyze and encourage the usage of the system outputs.

Lastly, analyzing technical feasibility is critical in the assessment of the practicability and success prospects for the Ice Age system implementation, with the initiative conforming to set objectives and utilizing existing toolsets and skills to generate significant improvements in glacier automated mapping.

1.1.2 Operational Feasibility

Evaluation of Staff Technical Ability

The technical practicality of the Ice Age project plan focuses on the evaluation of the functionalities of the staff that will be responsible for the project as well as the functionality of the technology that will be infused into the project. This evaluation checks on the ability of the team members to manage and drive the deep learning models, Incorporate the multisource remote sensing data and analyze the outcomes correctly.

Worthiness of the Problem and Solution

A part of the operational feasibility is to find out whether the problem tackled by the “Ice Age” project, namely debris-covered glacier monitoring, is really important to be deserving to integrate much of technologies. Furthermore, it assesses whether all the offered solutions including the SGDNet model and application framework, play a positive role in addressing all the envisaged environmental issues in the Himalaya-Karakoram region.

Stakeholder Perception
Another aspect of operational feasibility is identifying the perceptions of all the relevant end-users in the organization as well as the manager on the problem statement and its solutions. Development of these envisaged end-user perspectives contributes significantly to fine tune the goals of the project and achieve greater conformity to meet the end-users' requirements thereby helping to optimise the overall improvement and acceptability of the project.

By performing this operational feasibility assessment within the framework of the "Ice Age" project, aspects beyond technical applicability of the methods are covered, such as practicality, relevance, and potential impact as perceived by the stakeholders, this provides the basis for a successful implementation and sustainability of the project.

1.1.2 Economic Feasibility

The economic analysis of the Ice Age project cannot be a OPTIONS without considering the feasibility of its benefit-cost narration. This evaluation involves two essential components: The first and second elements of the program are cost estimates and benefit estimates.

Cost Estimates
Cost estimates are divided into two main categories:

Development or Acquisition Costs (One-time): This entails the financial resources and capital that is needed at the start or at the beginning to set up or purchase basic structures, equipment, and skills that will be crucial in the execution of the Ice Age project. It is a technique of designing the project in incremental phases and then using models to calculate costs as closely as possible. These estimates are benchmarks with historical data of such similar projects.

Maintenance and Operation Costs (Ongoing): These are the costs that are incurred frequently throughout the lifecycle of the Ice Age project, as the project requires funds to ensure that it is maintained and updated, as well as to secure support and operations. Calculating these costs entails projecting the amount of money that will be required to keep the project running incessantly with efficiency in the future.

Benefit Estimates
Benefit estimates encompass both tangible and intangible benefits:

Tangible Benefits: Some of tangible advantages that can be attributed to the effective management including the following; The cost reduction, the increase in revenues, and the overall efficiency. As for Ice Age, the persons may benefit in terms of improved practices of monitoring glaciers and more effective resource organization.

Intangible Benefits: These are all beneficial although they are difficult to assign actual monetary values. Prominent examples include increased precision of data, improved decision-making heuristics, satisfaction among the employees, and strengthening the reputation for monitoring the environment.

Hence, in the context of Ice Age, economic feasibility can be understood in terms of costs and benefits that need to be reckoned with. This way, aspects like costs of production, expected revenue and that of the returns can help stakeholders make wise decisions on the feasibility of the project.

1.1.4 Schedule Feasibility

Project planning and management are some of the key components, and this cannot fail to mention the time factor in relation to Ice Age. Schedule feasibility is about evaluating the possibilities of executing the project plan from the time estimations table within the necessary time with the required endowment and personnel. It therefore requires a scenario per phase in order to enable one to set realistic time horizons to be met during the project life cycle. These performance indicators, therefore, include the optimization of available time, organization of work tasks, resources, and timeframes for monitoring project performance. To that end, Ice Age will ensure that the schedule proposed in the current project plan is as realistic and achievable as possible, which will help it attain its objective of efficiency and timely delivery.

1.1.5 Specification Feasibility

Specification feasibility assesses the clarity, completeness, and boundaries of project requirements:

Clarity of Requirements:

System Features: When defining the features that the system ought to consist of such as traces of glacier boundary detection, classification, and monitoring, then one should do this with clarity.

Data Requirements: Describe the types and sources of multispectral imagery required for conclusion-making related to glaciers.

User Interaction: Identify interface features working as user attractions (login button, dashboard button, image array input) and features relevant to the system operation.

Scope Boundaries Assessment:

Project Scope: Demarcate line of viable action Train the highlight on automating glacier surveillance within the region encompassing Himalaya-Karakoram Himal using deep learning.

Exclusions: Code redundancy, explicitly marking out other features or functionalities that are not needed presently or in the immediate future.

Integration Points: Point out here on what aspects or process should the client focus when connecting with another system or data (e. g. Also included in the package are the required prerequisites for comprehensive glacier evaluation, such as climatic data base and geographic databases.

1.1.6 Information Feasibility

In our project information feasibility examines data credibility, relevancy and accuracy as key ways through which we measure the appropriateness of data in meeting certain project objectives. It includes determining the missing and redundant information, evaluating the credibility of sources, and checking if data collected corresponds to the project objectives. Reliability encompassing the feasibility of information also defines consistencies and timeliness which are important factors influencing social decisions and positive outcomes while implementing a project.

1.1.7 Motivational Feasibility

Motivational feasibility assesses the readiness and commitment of client staff to effectively and promptly execute necessary project tasks:

Employee Engagement: Assess the amount of interested and passionate the staff of the client company is towards the new technology that will enable glacier surveillance automation.

Skill Acquisition: Evaluate readiness of the staff for developing relevant competencies regarding the manifestations of the features, such as deep learning interpretation and geospatial analytics.

Change Management: Assess the readiness of staff to embrace of new working techniques and process brought about by the automated system.

Leadership Support: Assess the level of organizational support and promotion that leaders extend in order to enhance the success of the system adoption and incorporation into organizational processes.

Training and Development: Establish the attitudes of the staff towards continued training and development programs for improving their proficiency in deploying the system for monitoring and analyzing glaciers.

1.1.8 Legal & Ethical Feasibility

Ice Age project entails careful consideration of legal and ethical aspects to ensure compliance and ethical conduct throughout its operations:

Data Privacy and Security: Ice Age complies the policy of privacy keeping the identity of the users, the multispectral imagery and the geospatial data secret. Amidst changing trends and innovative modes of operating, measures such as encryption and access control are put in place to ensure that sensitive information is not prone to malicious attacks or intrusion.

Intellectual Property Rights: Copyright considerations are held in high regard due to the position of the movie in the animation business. The use of any proprietary algorithms, models, or data processing techniques is as per the classified level. It is crucial to follow the rules of data sourcing and annotate any original ideas: contracts with data sources and partners help to stipulate all the rights for using the intellectual property.

Ethical Guidelines: In this light, Ice Age does provide an ethical framework for the use of the kind of environmental technology the company employs when managing the climate. This touches on issues of accountability where data collection methods must be disclosed while data utilization must be done after seeking consent from the concerned parties where necessary; and where the project results in effects on scientific research or environmental conservation, the impacts must be positive.

Liability and Risk Management: The possibility of such a threat to exist is unusual but it is identified and managed in the project for automated data processing and interpretation. Unintended storage and usage liabilities are mitigated through contractual agreements with all relevant stakeholders, as well as the users of the system in terms of their obligations and the capabilities and limitations of the system.

Environmental Impact: Through its mission of presenting updated research information on glacier evaluations, Ice Age is aimed at contributing to environmentalism. Some of the limitations are on ethical grounds such as reduction of the impact that is made on environment during conducting the study and ensuring that the project is sustainable in an aspect that is in harmony with the principles of conservation.

Compliance: Ice Age currently respects state and national laws as well as international laws that have been put in place concerning environmental auditing, data privacy, and information technology regulation as a business organization. The implementation of audit and reviews is useful to check for compliance regularly besides adapting to changes in laws.

Stakeholder Engagement: Ice Age always involves stakeholders such as various communities, researchers, and governments in matters of moral concern and success in the decision making process. The present AAI approach leads to the development of trust, effective communication and understanding of each other in relation to the project implementation and utilization of the results.

1.2 Project/Product Scope

The automated debris glacier detection system is a powerful new tool to re-invigorate glacier mapping by providing deep learning and multisource remote sensing data. The specification of requirements identifies the elements of the system to be developed, its constraints, and the measures of effectiveness, which offers a schematic plan for work.

System Functionalities
The core functionalities of the system encompass:

Data Acquisition:

- **Data Sources:** It will also establish a connection with reliable remote-sensing data suppliers such as European Space Agency's Sentinel-2 by integrating multisource data including Landsat-8 and ASF Alaska.

- **Data Types:** The system will establish a set of diverse data types, as pointed out below:

  - Optical data (visible, near-infrared, shortwave infrared) for spectral information
  - Radar data (coherence images) for detailed surface structure analysis (Subject to data availability)
  - Elevation data (ALOS DEM) for accurate terrain representation
  - Slope data for understanding topographic variations

Deep Learning Model (SGDNet):

- **Pre-trained Model Integration:** Specifically, the system will build on the pre-trained deep neural network (DNN), named Seasonal Glacier – Debris Net (SGDNet), which has been demonstrated effective for debris-covered glacier mapping.

- **Model Functionality:** In this respect, multisource data shall be obtained Some of the multisource data include; SGDNet shall be used to differentiate the acquired multisource data between supraglacial debris (SGD) and periglacial debris (PGD).

Prediction and Output:

- **User Interface:** Web based graphical user interface shall be designed using a tool called Owl Framework which is a JavaScript based tool for providing smooth and easily navigable interfaces.

- **Frontend Features:** The basic actions that will be supported by the web interface include the following:

    - One of the most vital features that any website should incorporate is the ability to signup and Login to offer client a secure user access.
    - Application for users: Personal control panel that allows easy managing of tasks and data.
    - Upload an Image for Glacier Analysis for any user to upload any new imagery related to glaciers.
    - In order to present the results in a more easily understandable fashion it was necessary to visualize the shape and boundary of the predicted glacier.
    - Functionality to output the results (the suggested glacier delineation) in raster format for further processing.

Backend Integration:

- **Backend Development:** The back-end part will be created with Python and implemented with the use of the Odoo 17 Enterprise Framework to guarantee the efficient and reliable development.

- **Backend Responsibilities:** Some of what the backend will address include:

    - Data storage and management.
    - This is more feasible if the developed system will be integrated with remote sensing data sources.
    - In this case, the evaluation involves interacting with a pre-trained SGDNet models to get further analysis.
    - Processing and visualization of predicted glacier boundaries.
    - Account management / User management.

System Limitations

While the system offers robust functionalities, it is crucial to acknowledge its limitations:

- **Data Dependency:** The system's performance is inherently dependent on the availability and quality of multisource remote sensing data. Data gaps or inconsistencies may impact prediction accuracy.
- **Current Scope Exclusions:** The current scope excludes certain functionalities, including:

    - Terrain correction of input data for enhanced accuracy
    - Uncertainty quantification in model predictions to assess

confidence levels

- Advanced data visualization tools beyond basic boundary maps for comprehensive analysis

Future Enhancements

As the project progresses, potential enhancements include:

- **Data Integration:** Expanding data sources to include additional remote sensing data or in-situ observations for improved accuracy.
- **Model Development:** Investigating the development of an in-house deep learning model tailored to specific user requirements or regional characteristics.
- **Advanced Functionalities:** Implementing terrain correction and uncertainty quantification functionalities to enhance data quality and reliability.
- **Visualization Tools:** Creating advanced data visualization tools, such as 3D models and interactive maps, for comprehensive glacier analysis and communication.

Exclusions

To ensure project focus and feasibility, certain aspects are excluded from the current scope:

- **Mobile Application Development:** While the system will prioritize a responsive web interface built with Owl Framework and Odoo, a mobile application may be considered for future enhancements.
- **On-site Data Collection:** The system relies on pre-existing remote sensing data sources and does not encompass on-site data collection capabilities.

Success Criteria

The project's success will be evaluated based on the following criteria:

- **Functional Implementation:** Successful development of a user-friendly web interface that enables seamless data upload, visualization, and export of predicted glacier boundaries.

    - Responsive design across different devices
    - Integration of Signup, Login, Dashboard, and other user-centric features

- **Model Integration:** Effective integration of the pre-trained SGDNet model to accurately detect debris cover and map glacier boundaries.

- **Backend Integration:** Robust backend development using Python and Odoo for data management, model interaction, and result processing.

1.3 Project/Product Costing

Financial planning is crucial for my automated debris glacier detection system. Key costs include developing the web interface and backend using Owl Framework and Odoo, potential fees for remote sensing data access (Sentinel-2, Landsat-8, ASF Alaska), and cloud hosting fees for system operation. To estimate the overall budget, I'll consider expert advice, industry benchmarks, and a breakdown of individual development and infrastructure costs.

1.3.1 Project Cost Estimation by using COCOMO’81 (Constructive Cost Model)

Function-oriented software metrics use a measure of the functionality delivered by the application as a normalization value. Since ‘functionality’ cannot be measured directly, it must be derived indirectly using other direct measures. Function-oriented metrics were first proposed by Albrecht, who suggested a measure called the function point. Function points are derived using an empirical relationship based on countable (direct) measures of software’s information domain and assessments of software complexity.

Function Point Analysis can provide a mechanism to track and monitor scope creep. Function Point counts at the end of requirements; analysis, design, code, testing, and implementation can be compared. The function point count at the end of requirements and/or designs can be compared to function points actually delivered. If the project has grown, there has been scope creep. The amount of growth is an indication of how well requirements were gathered by and/or communicated to the project team. If the amount of growth of projects declines over time it is a natural assumption that communication with the user has improved.

Function points are computed by completing the table shown below. Five information domain characteristics are determined and counts are provided in the appropriate table location.

Information Domain Values

Number of user inputs: Each user input that provides distinct application-oriented data to the software is counted. Inputs should be distinguished from inquiries, which are counted separately.
Number of user outputs: Each user output that provides application-oriented information to the user is counted. In this context output refers to reports, screens, error messages, etc. Individual data items within a report are not counted separately.
Number of user inquiries: An inquiry is defined as an on-line input that results in the

generation of some immediate software response in the form of an on-line output. Each distinct inquiry is counted.

Number of files: Each logical master file (i.e., a logical grouping of data that may be one part of a large database or a separate file) is counted.

Number of external interfaces: All the machine-readable interfaces (e.g., data files on storage media) that are used to transmit information to another system are counted.

Once these data have been collected, a complexity value is associated with each count. Organizations that use function point methods develop criteria for determining whether a particular entry is simple, average, or complex. Nonetheless, the determination of complexity is somewhat subjective.

To compute function points (FP), the following relationship is used:

FP est.=Count Total×[0.65+0.01×(ΣF i)]

Where count total is the sum of all FP entries obtained from the table below is the value adjustment factor (VAF) based on 14 general system characteristics (GSCs) that rate the general functionality of the application being counted. Each characteristic has associated descriptions that help determine the degrees of influence of the characteristics. The degrees of influence range on a scale of zero to five, from no influence to strong influence.

General System Characteristics:

1. Data communications
2. Distributed data processing
3. Performance
4. Heavily used configuration
5. Transaction rate
6. On-Line data entry
7. End-user efficiency
8. On-Line update
9. Complex processing
10. Reusability
11. Installation ease
12. Operational ease
13. Multiple sites
14. Facilitate change

Calculations

Type of Components and Complexity:

Type of Component	Complexity of Components	Total
	Low	Average
External Inputs		5 x 4 = 20
External Outputs		1 x 5 = 5
External Inquiries		
Internal Logical Files		2 x 7 = 14
External Interface Files		2 x 7 = 14
Total Number of Unadjusted Function Points	53	
Multiplied Value Adjustment Factor	[0.65 + 0.01 * Σ(Fi)]	
Total Adjusted Function Points	Calculated Below	

Total Number of Unadjusted Function Points: 53

Value Adjustment Factor (VAF):

Given 14 General System Characteristics (GSCs), assume moderate influence for each characteristic:
If we assume each characteristic has an influence degree of 3 (mid-scale for 0-5 range), then Σ(Fi) = 3 * 14 = 42

Function Point Adjustment Formula:

FP est.=53×[0.65+0.01×42]=53×[0.65+0.42]=53×1.07=56.71

Thus, the Total Adjusted Function Points are 56.71.

Additional Calculations
Using the formulae provided:

1. **Cost / FP:**

$$\text{Cost per FP}=\frac{\text{Productivity Parameter}}{\textit{Labour Rate}}$$

2. **Total Project Cost:**

$$\text{Total Project Cost}=56.71\times(\text{Cost per FP})$$

3. **Total Estimated Efforts:**

$$\text{Total Estimated Effort}=\frac{56.71}{\text{Productivity Parameter}}$$

1.4 CPM - Critical Path Method

The Critical Path Method (CPM) is a project management tool that represents the sequence of activities and events in a project network. The CPM helps in:

- Providing a visual representation of the project timeline.
- Estimating the time required for project completion.
- Identifying the tasks that are critical to maintaining the project schedule.

For our project, the CPM analysis reveals the following schedule, with a total duration of approximately 15.5 months:

Activity	Task Name	Immediate Predecessor	Duration (Months)
T-1	Group Meetings	None	0.5
T-2	Meeting with Supervisor	T-1	0.5
T-3	Project Proposal	T-2	1
T-4	Requirements Gathering	T-3	1.5
T-5	Feasibility Analysis	T-4	1
T-6	Define Project Scope	T-5	0.5
T-7	Market Research	T-6	1
T-8	Cost & Benefit Analysis	T-7	0.5
T-9	Develop Signup Interface	T-8	1
T-10	Develop Login Interface	T-8	1
T-11	Develop Image Upload	T-8	0.5
T-12	Develop Results Show	T-11	0.5
T-13	Import Libraries	T-9, T-10	0.5
T-14	Import Dataset	T-13	0.5
T-15	Reshape Data	T-14,T-13	0.5
T-16	Split Dataset	T-15	0.5
T-17	Scale Data	T-16	0.5
T-18	Define Model	T-17	1

T-19	Train Model	T-18	1
T-20	Evaluate Model	T-19,T-18	1
T-21	Predict on New Data	T-20	0.5
T-22	Export Results	T-21	0.5
T-23	Analyze Results	T-22	0.5
T-24	Write Documentation	T-23	0.5
T-25	Save Model	T-24	0.5
T-26	Mobile App Development	T-20	3

The table below outlines the CPM analysis:

Activity	Task Name	Duration (Months)	ES	EF	LS	LF	TS	FS
T-1	Group Meetings	0.5	0	0.5	0	0.5	0	0
T-2	Meeting with Supervisor	0.5	0	0.5	0	0.5	0	0
T-3	Project Proposal	1	0	1	0	1	0	0
T-4	Requirements Gathering	1.5	1	2.5	1	2.5	0	0
T-5	Feasibility Analysis	1	2.5	3.5	2.5	3.5	0	0
T-6	Define Project Scope	0.5	3.5	4	3.5	4	0	0
T-7	Market Research	1	4	5	4	5	0	0
T-8	Cost & Benefit Analysis	0.5	5	5.5	5	5.5	0	0
T-9	Develop Signup Interface	1	5.5	6.5	5.5	6.5	0	0
T-10	Develop Login Interface	1	5.5	6.5	5.5	6.5	0	0
T-11	Develop Image Upload	0.5	5.5	6	5.5	6	0	0
T-12	Develop Results Show	0.5	5.5	6	5.5	6	0	0
T-13	Import Libraries	0.5	6.5	7	6.5	7	0	0
T-14	Import Dataset	0.5	7	7.5	7	7.5	0	0
T-15	Reshape Data	0.5	7.5	8	7.5	8	0	0
T-16	Split Dataset	0.5	8	8.5	8	8.5	0	0
T-17	Scale Data	0.5	8.5	9	8.5	9	0	0
T-18	Define Model	1	9	10	9	10	0	0
T-19	Train Model	1	10	11	10	11	0	0
T-20	Evaluate Model	1	11	12	11	12	0	0
T-21	Predict on New Data	0.5	12	12.5	12	12.5	0	0
T-22	Export Results	0.5	12.5	13	12.5	13	0	0
T-23	Analyze Results	0.5	13	13.5	13	13.5	0	0
T-24	Write Documentation	0.5	13.5	14	13.5	14	0	0
T-25	Save Model	0.5	14	14.5	14	14.5	0	0
T-26	Mobile Application Development	1	14.5	14	15.5	15	0	0

Network Diagram

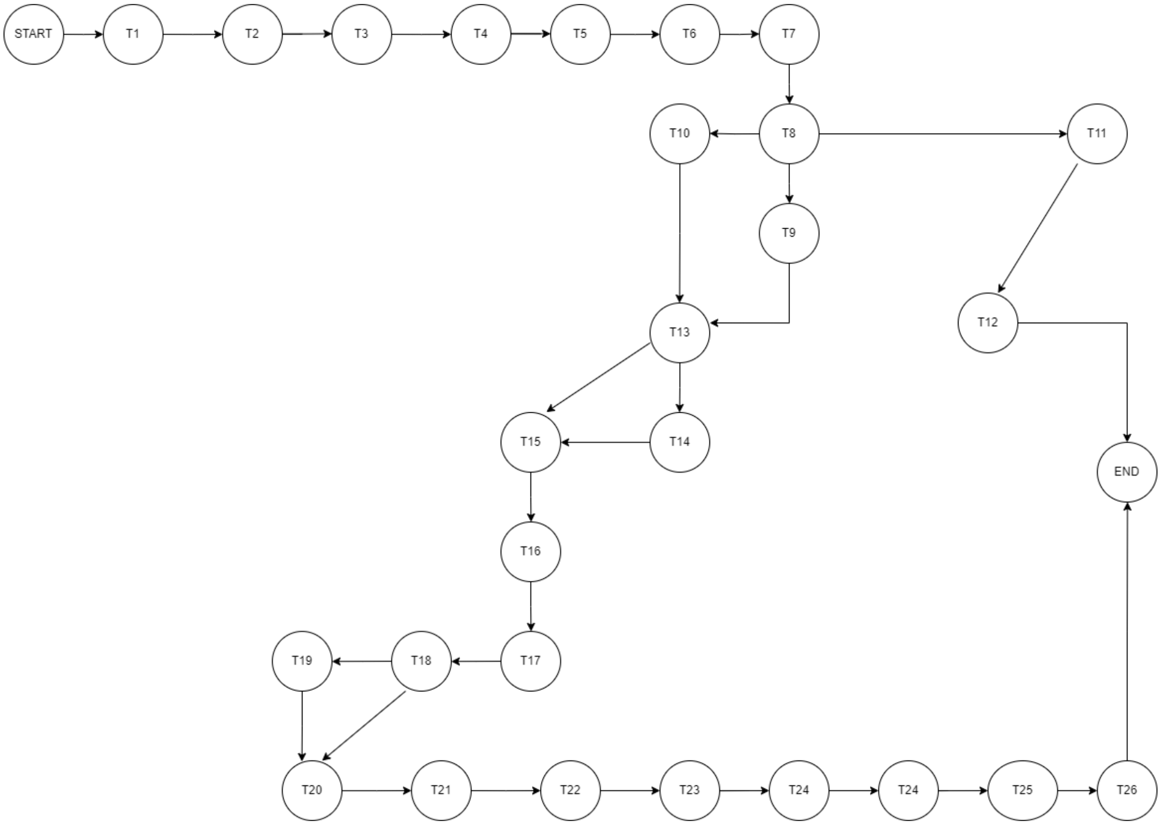


Figure 1: Network Diagram

NETWORK DIAGRAM (CPM)

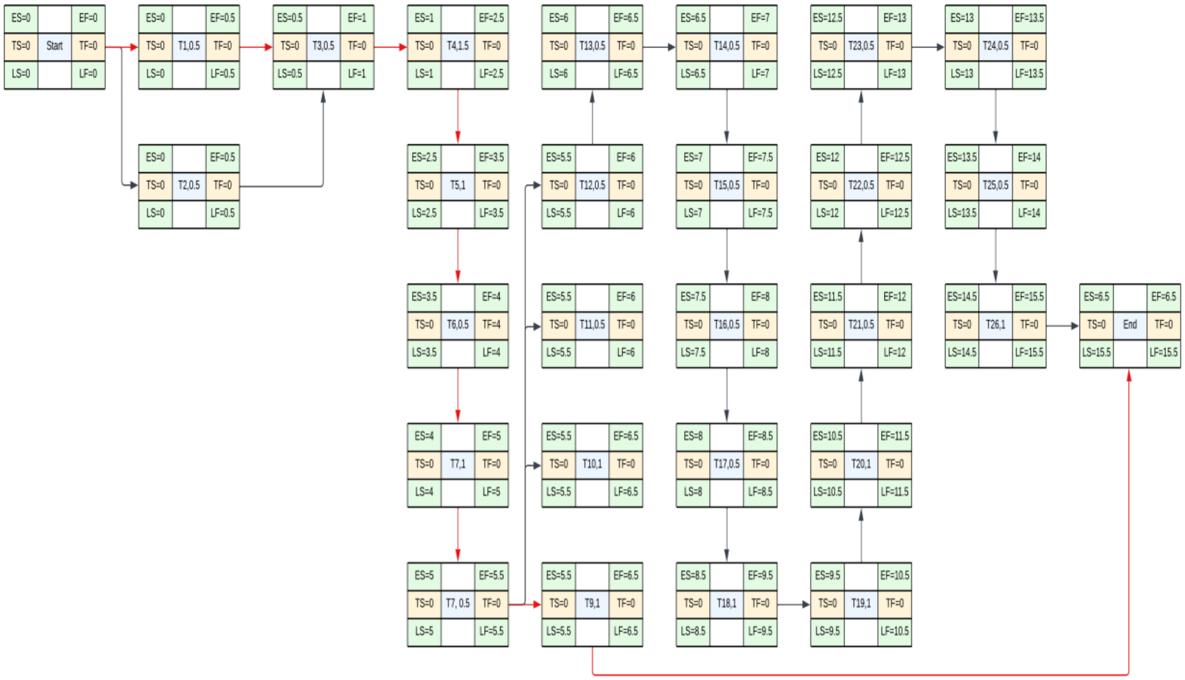


Figure 2: Network Diagram (CPM)

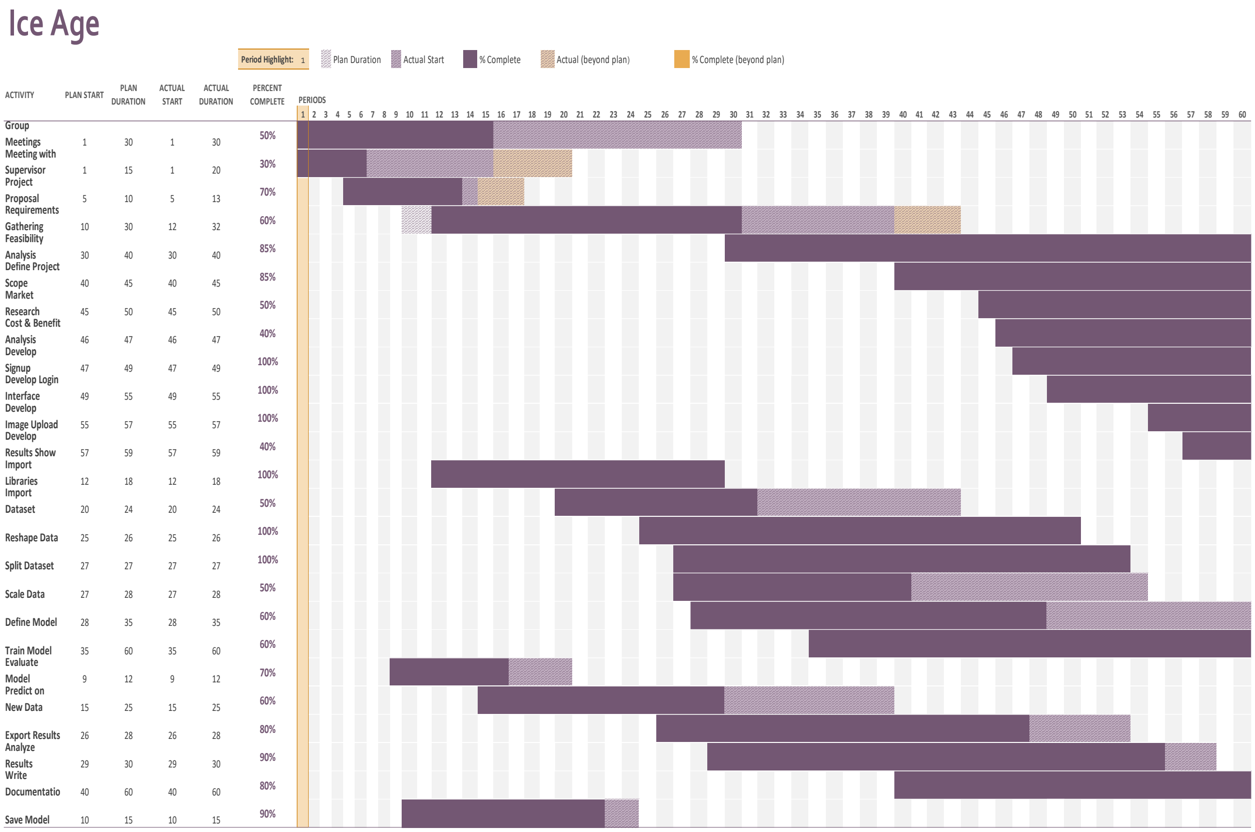
Critical Path Analysis for Project Timeline of Approximately 15.5 Months:

Possible Critical Paths:

1. **T-1 → T-2 → T-3 → T-4 → T-5 → T-6 → T-7 → T-8 → T-9 → T-13 → T-14 → T-15 → T-16 → T-17 → T-18 → T-19 → T-20 → T-21 → T-22 → T-23 → T-25 → T-26**
   - Total Duration: 0.5 + 0.5 + 1 + 1.5 + 1 + 0.5 + 1 + 0.5 + 1 + 0.5 + 0.5 + 0.5 + 0.5 + 1 + 1 + 1 + 0.5 + 0.5 + 0.5 + 0.5 + 3 = 15.5 months
2. **T-1 → T-2 → T-3 → T-4 → T-5 → T-6 → T-7 → T-8 → T-9 → T-13 → T-14 → T-15 → T-18 → T-19 → T-20 → T-21 → T-22 → T-23 → T-25 → T-26**
   - Total Duration: 0.5 + 0.5 + 1 + 1.5 + 1 + 0.5 + 1 + 0.5 + 1 + 0.5 + 0.5 + 0.5 + 1 + 1 + 1 + 0.5 + 0.5 + 0.5 + 0.5 + 3 = 15.5 months
3. **T-1 → T-2 → T-3 → T-4 → T-5 → T-6 → T-7 → T-8 → T-9 → T-13 → T-15 → T-18 → T-19 → T-20 → T-21 → T-22 → T-23 → T-25 → T-26**
   - Total Duration: 0.5 + 0.5 + 1 + 1.5 + 1 + 0.5 + 1 + 0.5 + 1 + 0.5 + 0.5 + 1 + 1 + 1 + 0.5 + 0.5 + 0.5 + 0.5 + 3 = 15.5 months

1.5 Gantt chart

Use MS Project to create a Gantt chart visualizing our glacier detection system's development timeline, including task durations and dependencies. The Gantt chart, built in MS Project, will map project tasks, their durations, and crucial milestones for our automated debris glacier detection system.



ACTIVITY	PLAN START	PLAN DURATION	ACTUAL START	ACTUAL DURATION	PERCENT COMPLETE
Group Meetings	1	30	1	30	50%
Meeting with Supervisor	1	15	1	20	30%
Project Proposal	5	10	5	13	70%
Requirements Gathering	10	30	12	32	60%
Feasibility Analysis	30	40	30	40	85%
Define Project Scope	40	45	40	45	85%
Market Research	45	50	45	50	50%
Cost & Benefit Analysis	46	47	46	47	40%
Develop Signup	47	49	47	49	100%
Develop Login Interface	49	55	49	55	100%
Develop Image Upload	55	57	55	57	100%
Develop Results Show	57	59	57	59	40%
Import Libraries	12	18	12	18	100%
Import Dataset	20	24	20	24	50%
Reshape Data	25	26	25	26	100%
Split Dataset	27	27	27	27	100%
Scale Data	27	28	27	28	50%
Define Model	28	35	28	35	60%
Train Model	35	60	35	60	60%
Evaluate Model	9	12	9	12	70%
Predict on New Data	15	25	15	25	60%
Export Results	26	28	26	28	80%
Analyze Results	29	30	29	30	90%
Write Documentatio	40	60	40	60	80%
Save Model	10	15	10	15	90%

Figure 3: Gantt Chart

1.6 Introduction to Team member and their skill set

The automated debris glacier detection system takes flight on the wings of a dedicated and skilled team. Each member brings a unique melody to the development symphony, ensuring a harmonious and successful outcome.

- **Muhammad Usman Ghias: The Deep Learning Maestro:** A seasoned developer, Muhammad Usman wields the power of deep learning in Python. His mastery extends to Odoo, a robust open-source framework for business applications. We can expect him to orchestrate the backend development, particularly the seamless integration of the pre-trained SGDNet model for accurate debris cover detection.
- **Alisha Sultan: The User Interface (UI) & Deep Learning Alchemist:** Alisha is a multi-talented developer who excels in both frontend development and deep learning using Python. Her expertise in crafting user interfaces (UI) and her keen understanding of UX principles, honed through her experience with Figma, will be invaluable in composing an intuitive and user-friendly web interface. Additionally, her deep learning skills with Python allow her to contribute to potential improvements within the model itself. This ensures a captivating and user-centered experience while also exploring optimizations for the deep learning aspects of the system.
- **Kainat Bashir: The Versatile Developer:** Kainat possesses a strong foundation in deep learning using Python alongside the ability to develop captivating frontends. This versatility allows her to contribute to both the backend model integration and the user interface development. Her involvement can create a cohesive experience, where the system's functionality and user interaction flow seamlessly together. We can also highlight her expertise in Python by mentioning she can leverage it for various tasks within the system, not just deep learning.
- **Qurban Hanif: The Full-Stack Alchemist:** While Qurban's primary expertise lies in ReactJS, his proficiency in Python suggests the potential for a full-stack development role. He can leverage his Python skills to contribute to both frontend and backend aspects, utilizing Python's versatility for various tasks within the system. Imagine him as the alchemist, transforming raw code into a functional and robust system.
- **Muhammad Usman Zahid: The Infrastructure Architect:** A crucial member for building a strong foundation, Muhammad Usman boasts expertise in computer networks, Python, and AWS (Amazon Web Services). His knowledge will be instrumental in designing and managing the cloud resources for system operation. This ensures scalability, reliability, and accessibility for users across different locations. Think of him as the architect, ensuring the system has a solid and scalable infrastructure to operate upon.

With this diverse team, we have a winning combination of skills: deep learning, Python development, frontend development, UX design, and cloud expertise. This powerful synergy positions us for the successful development and deployment of the automated debris glacier detection system, ultimately revolutionizing glacier mapping and making a significant contribution to the field of environmental science.

1.7 Tools and Technology with reasoning

The automated debris glacier detection system leverages a strategic combination of tools and technologies to ensure efficient development and functionality across various platforms. Let's delve into the rationale behind our choices:

Understanding Needs and Constraints:

- **Development Process (Iterative):** We plan to adopt an iterative development process, fostering continuous improvement through frequent user feedback. This necessitates tools that support:
    - **Version Control System (Git):** Git will be our lifeline, meticulously tracking code changes, managing different versions, and facilitating seamless collaboration throughout the development process. GitHub, a popular Git hosting platform, will provide a central repository for code, issue tracking, and collaboration features.
    - **Automated Testing Framework (Pytest):** Pytest, our automated testing champion, will streamline unit and integration testing. It will catch bugs early and prevent regressions as we iterate on the system.
- **Target Platforms:**
    - **Web Application (Owl):** A web application, built with the lightweight Owl framework (JavaScript), is our primary platform. Owl's focus on minimal dependencies and responsive design guarantees a smooth and user-friendly experience across various devices.
    - **Optional Mobile Application (Flutter):** Depending on project scope and resources, we might explore developing a mobile application using Flutter. This cross-platform framework from Google allows us to create native-looking mobile experiences for both Android and iOS with a single codebase, enhancing accessibility for users on the go.
- **Programming Languages:**
    - **Python:** Python serves as the foundation of our system due to its:
        - **Readability:** Clear and concise syntax fosters collaboration and simplifies maintenance.
        - **Extensive Libraries:** Python boasts a rich ecosystem of libraries

that empower us:

- **Deep Learning (Scikit-learn, TensorFlow, PyTorch):** To leverage pre-trained models like SGDNet or potentially develop custom models for debris cover detection in the future.
- **Data Manipulation (NumPy, Pandas):** To efficiently handle and analyze multisource remote sensing data.
- **Web Development (Django, Flask - Backend; Owl - Frontend):** To build robust backend functionalities and a user-friendly web interface.

❖ **Existing Tools:**

- **Pre-trained SGDNet Model:** We'll capitalize on this pre-trained deep learning model for debris cover detection. This eliminates the need to develop a model from scratch, saving valuable time and resources.

❖ **Development Team Distribution:**

- **Potential Geographic Dispersion:** If our team is geographically scattered, we'll bridge the distance with:

  ➢ **Collaboration Tools (Slack, Microsoft Teams):** These tools will keep communication flowing, streamline project management, and enable real-time collaboration despite physical separation.

❖ **Project Size:**

- **Open-Source (Git, Pytest, Owl):** Open-source tools optimize budget allocation for core functionalities.
- **Cost-effective Cloud Solutions (AWS, depending on usage):** We'll leverage cloud services efficiently to manage infrastructure costs.

Additional Tools:

❖ **QGIS:** QGIS, a free and open-source Geographic Information System (GIS) software, might be instrumental in:

- **Data Preprocessing:** Preparing and analyzing geospatial data (e.g., satellite imagery) relevant to glacier cover and debris detection.
- **Visualization:** Visualizing and exploring geospatial data to aid in understanding glacier dynamics and model development.

❖ **PyCharm:** PyCharm, a powerful Integrated Development Environment (IDE) specifically designed for Python, can significantly enhance our development experience by:

- **Code Completion and Refactoring:** Streamlining code writing and improving code quality.
- **Debugging Tools:** Facilitating efficient debugging and troubleshooting.
- **Version Control Integration:** Simplifying version control workflows within the IDE.

Justification for Tool Selection:

The chosen tools strike a delicate balance between:

- **Effectiveness:** Addressing development needs and delivering desired functionalities.
- **Efficiency:** Streamlining workflows, minimizing development time, and optimizing resource allocation.
- **Cost-effectiveness:** Utilizing open-source tools and exploring cost-efficient cloud solutions whenever possible.

This combination of tools ensures a robust development process, a user-friendly web application and for a mobile app, and efficient data handling capabilities, ultimately contributing to a successful and impactful automated debris glacier detection system.

1.8 Vision Document

Project Overview

Our project aims to revolutionize glacier mapping by developing an automated debris glacier detection system. Climate change poses a significant threat to glaciers worldwide, and understanding their dynamics is crucial for informed environmental conservation strategies. This system will address the increasing need for efficient and accurate glacier debris cover detection.

Stakeholders

- ❖ **Primary Stakeholders:**
  - Glaciologists and researchers
  - Environmental policymakers
  - Conservation organizations
- ❖ **Secondary Stakeholders:**
  - The general public interested in climate change and environmental issues

- Educational institutions

Problem Statement

Manual glacier debris cover mapping is a time-consuming and resource-intensive process, often relying on visual analysis of satellite imagery. This approach is prone to human error and inconsistencies, hindering large-scale and timely monitoring efforts.

System Vision

We envision a user-friendly **web application (primary platform)** that automates debris glacier detection. This system will leverage deep learning models and geospatial data analysis to:

- **Reduce reliance on manual mapping:** The system will automate debris cover detection, significantly saving time and resources for researchers and environmental organizations.
- **Improve accuracy and consistency:** By leveraging deep learning algorithms, the system will provide objective and consistent results, minimizing human error in debris cover assessment.
- **Enhance accessibility:** The web-based platform will offer easy access for researchers and stakeholders worldwide, facilitating collaboration and data sharing.
- **Support informed decision-making:** By providing accurate and timely information about debris cover, the system will empower policymakers and conservation efforts to develop effective strategies for glacier preservation.

Additionally, depending on project scope and resources, we will explore developing a complementary mobile application using Flutter. This cross-platform framework from Google allows us to create native-looking mobile experiences for both Android and iOS with a single codebase. A mobile application would:

- **Enhance accessibility:** Provide on-the-go access to the system's functionalities for researchers and stakeholders in the field.
- **Increase user engagement:** Offer a convenient way to interact with the system and its data.

Core Features

- Automated debris cover detection using pre-trained deep learning models (e.g., SGDNet)
- Integration with geospatial data sources (e.g., satellite imagery)
- User-friendly interface for uploading and analyzing data (optimized for both web and mobile if applicable)
- Visualization tools for exploring glacier cover and debris distribution

- Data export functionalities for further analysis and reporting

1.8.6 Success Criteria

The success of this project will be measured by:

- **Accuracy of debris cover detection:** The system should achieve high accuracy in identifying debris cover compared to manual mapping techniques.
- **User adoption:** The system should be user-friendly and adopted by researchers, environmental organizations, and policymakers.
- **Contribution to research and conservation:** The system should provide valuable data and insights to support glacier research and conservation efforts.

1.9 Risk List

This list outlines potential risks associated with developing the automated debris glacier detection system, categorized by their severity (High, Medium, Low).

High:

- **Data Availability and Quality:** Insufficient or unreliable geospatial data or satellite imagery could impact the accuracy of debris cover detection.
- **Model Performance:** The deep learning model might not achieve the desired level of accuracy in identifying debris cover.
- **Technical Expertise:** The development team might encounter challenges due to a lack of expertise in specific technologies (deep learning, geospatial analysis).
- **Project Scope Creep:** Unforeseen changes in project requirements or functionalities could lead to delays and budget overruns.

Medium:

- **Hardware and Infrastructure Limitations:** Computing power or storage capacity limitations could hinder development and processing.
- **Software Development Delays:** Unexpected issues during development could cause delays in completing the system.
- **External Dependency Delays:** Reliance on third-party tools or APIs could introduce delays if they are not readily available.
- **Stakeholder Misalignment:** Differing expectations or priorities among stakeholders could lead to project conflicts.

Low:

- **Power Outages and Network Disruptions:** Temporary disruptions could cause minor delays but have workarounds (backups, offline functionality).
- **Resource Availability:** Unexpected team member absences could cause minor

delays, mitigated by flexible scheduling or workload adjustments.

- **Open-Source Software Updates:** Updates to open-source libraries used in the project might require minor adjustments to maintain compatibility.
- **Documentation Gaps:** Incomplete or unclear documentation could lead to minor inefficiencies during development or user adoption.

Mitigation Strategies:

For each risk, a mitigation strategy will be developed to minimize its impact. These strategies might include:

- **Data source diversification and quality checks**
- **Rigorous model testing and refinement**
- **Team training and knowledge sharing**
- **Clear project scope definition and change management process**
- **Investment in adequate hardware and infrastructure**
- **Agile development methodologies and regular testing**
- **Contingency plans for external dependencies**
- **Open communication and stakeholder management**
- **Redundancy and backup systems**
- **Cross-training team members**
- **Regular software updates and compatibility checks**
- **Comprehensive and up-to-date documentation**

This risk list will be a living document, continuously updated as the project progresses. By proactively addressing potential risks, we can increase the likelihood of successful development and deployment of the automated debris glacier detection system.

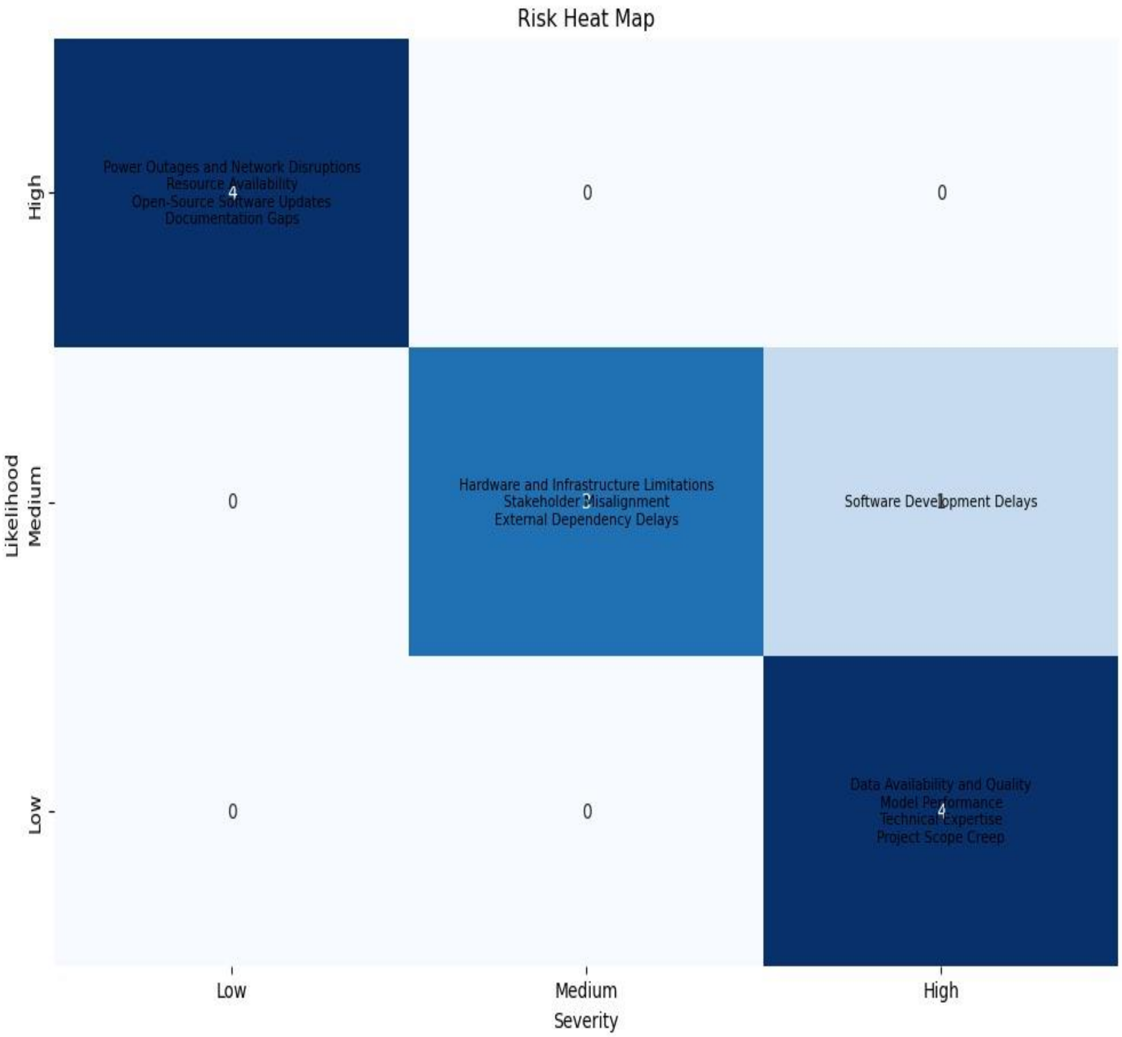


Figure 4: Risk Matrix

********************REQUIREMENTS ENGINEERING********************

1 Introduction

Developing an automated debris glacier detection system requires a deep understanding of user needs and translating them into a well-defined set of functionalities. **Requirements Engineering** provides a structured approach to achieve this. Through this process, we'll gather vital information from glaciologists, researchers, and environmental stakeholders to precisely capture their vision for the system's capabilities. By meticulously analyzing and documenting these requirements, we establish a clear roadmap for development, ensuring the final system effectively addresses critical tasks like debris cover mapping and data analysis.

Here, requirements specification is to be discussed. Requirements specification would lead to the following four steps:

- Identify external interfaces
- Development of context diagram
- Capture “shall statements
- Allocate requirements
- Prioritize requirements
- Development of requirements traceability matrix

1.1 Systems Specifications

The following are the clauses that must be included while describing the system specifications.

Introduction

This document outlines the system specifications for an automated debris glacier detection system. Glaciers are critical indicators of climate change, with debris cover significantly impacting melt rates and glacial health. This system will be a valuable tool for glaciologists, researchers, and environmental organizations, enabling them to monitor debris cover extent and dynamics more efficiently and at a larger scale.

Existing System

Currently, debris cover mapping relies heavily on manual analysis of satellite imagery. This process is time-consuming, resource-intensive, and prone to human error, making it challenging for large-scale monitoring efforts. Additionally, inconsistencies can arise due to subjective interpretations by different analysts.

Organizational Chart

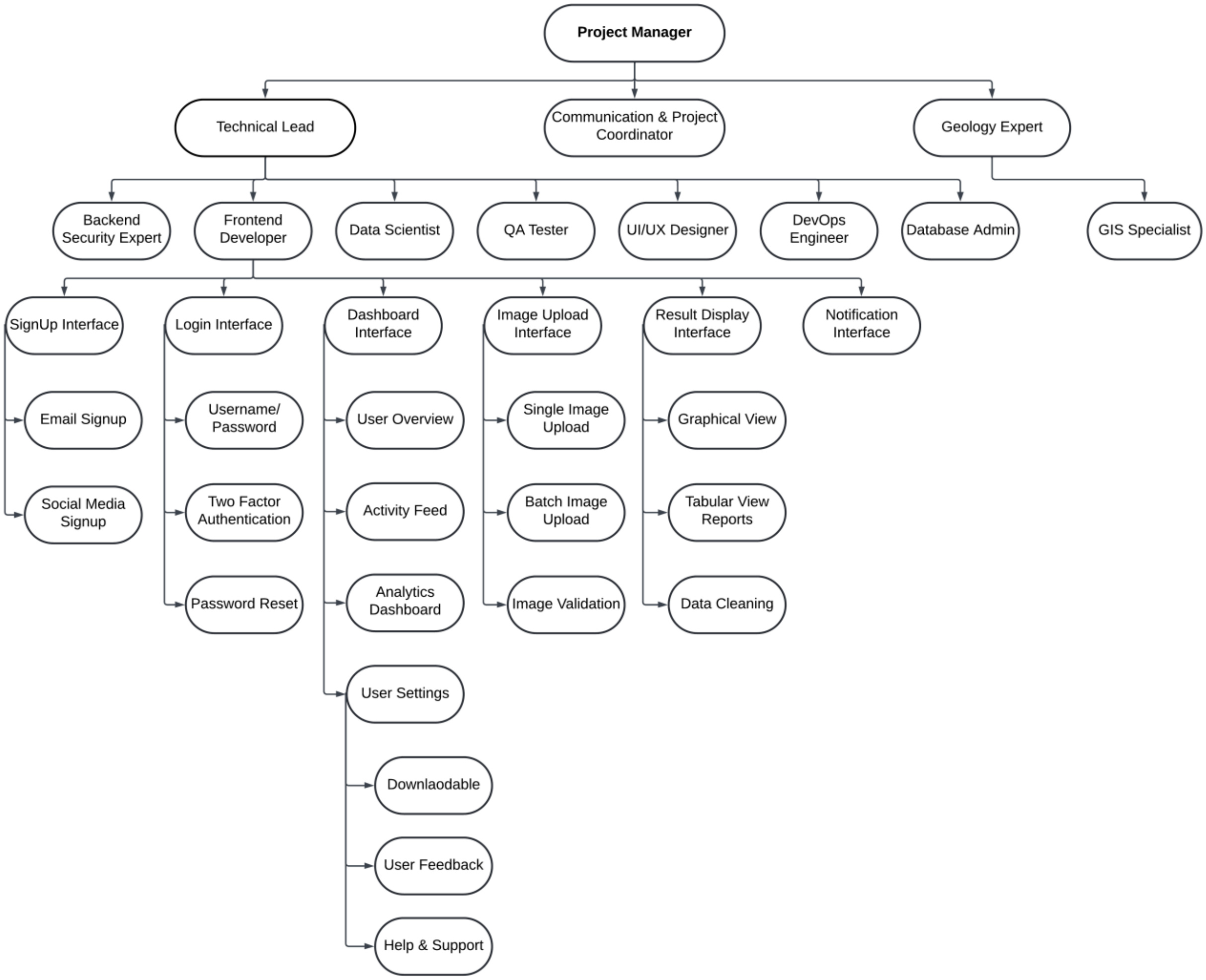


Figure 5: Organizational Chart

Scope of the System

This project focuses on developing a comprehensive solution with two potential deployment options:

- **Web-based Application (Primary Platform):** This user-friendly web application will be accessible through any standard web browser on desktops, laptops, or tablets with an internet connection. The web application will cater to researchers, glaciologists, and environmental organizations, providing them with in-depth data analysis and manipulation capabilities.
- **Mobile Application (Optional):** A secondary mobile application can be

developed as a complimentary tool for field personnel or researchers requiring on-site data access and basic functionalities. The mobile application would offer a streamlined interface for uploading images, viewing basic analysis results, and potentially capturing geospatial data in the field (using GPS functionality).

Both platforms (web and potential mobile app) will leverage deep learning models for automated debris cover detection on glaciers. The core functionalities will include:

- **Data Acquisition:**
  - The web application will allow users to upload geospatial data (primarily satellite imagery) in various formats commonly used in the scientific community.
  - The system will explore integration with established geospatial data sources (e.g., NASA Earth Observing System, USGS Earth Resources Observation and Science Center) to facilitate seamless data acquisition for specific regions or glaciers of interest.

- **Data Preprocessing:**
  - The system will perform automated preprocessing steps on the uploaded imagery to ensure data quality and consistency, such as format standardization, normalization, and potential cloud cover removal techniques.

- **Debris Cover Detection:**
  - The system will employ deep learning models trained on large datasets of labeled satellite imagery to automatically identify and delineate the extent of debris cover on glaciers.
  - The system may offer users the ability to choose between pre-trained models optimized for specific debris types or geographical regions (if data allows).

- **Data Visualization:**
  - The web application will provide interactive visualizations of the analyzed data, including high-resolution maps with clear overlays highlighting the extent and characteristics of debris cover.
  - Users will be able to explore the data through various visualization tools like charts and graphs depicting the percentage of debris cover over time or across different glacier regions.

- **Data Export and Analysis:**
  - The system will allow users to export the analyzed data (debris cover

maps, statistics) in various formats (e.g., GeoTIFF, CSV) for further analysis in external GIS software or generation of reports.

- The web application might offer basic data analysis functionalities like time series analysis of debris cover changes or comparison with other environmental data (e.g., temperature records).

1.1.4 Summary of Requirements (Initial)

- **Accuracy:** The system should achieve high accuracy in debris cover detection compared to manual methods, with clear metrics and validation procedures established.
- **User-friendliness:** Both web and mobile interfaces (if applicable) should be intuitive and user-friendly for researchers and stakeholders with varying technical backgrounds. The system should offer clear documentation, tutorials, and user support mechanisms.
- **Data Security:** The system should ensure the security and privacy of user-uploaded data, adhering to relevant data protection regulations.
- **Scalability:** The system should be scalable to handle large datasets from various geographical regions and accommodate future functionalities like advanced data analysis tools or integration with other environmental monitoring systems.
- **Performance:** The system should deliver results within reasonable timeframes, especially for the web application catering to potentially complex analyses.

These initial requirements will be further refined and elaborated upon throughout the requirements engineering process. Stakeholder input and iterative development will be crucial in ensuring the system meets the specific needs of the glaciology and environmental research communities.

1.2 Identifying External Entities

Following the two-phase approach for identifying external entities, we can delve deeper into our project's abstract:

Abstract:

This document outlines the system specifications for an automated debris glacier detection system. Glaciers are vital indicators of climate change, with debris cover significantly impacting melt rates and glacial health. This system will be a valuable tool for glaciologists, researchers, and environmental organizations, enabling them to monitor debris cover extent and dynamics more efficiently and at a larger scale.

Phase a: Over-Specifying Entities from Abstract

Based on the abstract, we can brainstorm a comprehensive list of potential external entities:

- **Glaciers (Primary Entity):** Geographical formations of interest for debris cover detection. The system will primarily focus on data acquisition and analysis related to glaciers.
- **Satellite Imagery Providers:** Organizations or platforms that provide satellite imagery data crucial for training the debris cover detection model and analyzing debris cover over time. (e.g., NASA Earth Observing System, USGS Earth Resources Observation and Science Center)
- **Ground Observation Teams (Optional):** Field research teams potentially collecting on-site data that could be integrated with the system in the future (e.g., high-resolution photos for model validation or additional data points).
- **Glaciologists:** Researchers specializing in the study of glaciers and their dynamics, who represent a core user group for the system. They will heavily rely on the system's functionalities for debris cover mapping and analysis.
- **Researchers (Broader Category):** A broader category encompassing scientists studying various aspects of glaciers and their environment, who might also find the system valuable for their research endeavors (e.g., climate change impact studies).
- **Environmental Organizations (Diverse Range):** Non-profit or governmental entities concerned with environmental monitoring and protection. These organizations can leverage the system for large-scale glacier health assessments and informing policy decisions.

Phase b: Refinement Based on Business Logic

Considering the system's functionalities and target users, we can refine the initial list:

- **External Data Sources:** This encompasses various sources of geospatial data, primarily satellite imagery providers. However, depending on future developments, it could potentially include other relevant environmental datasets (e.g., digital elevation models, temperature data).
- **Research Institutions:** This broader category includes universities, research institutes, and government agencies employing glaciologists and researchers who would utilize the system. These institutions might also contribute data or collaborate on model development.
- **End-Users (Primary Focus):** This refined category focuses on the individuals directly interacting with the system:

  - Glaciologists: A core user group for in-depth analysis of debris cover and glacier health.
  - Researchers affiliated with research institutions: These researchers might utilize the system for broader studies related to glaciers and their environment.
  - Environmental organization personnel: These users would benefit from the

system for large-scale monitoring and data-driven decision making.

Additional Considerations:

- **Data Repositories (Optional):** Depending on the implementation, external data repositories for storing and managing user-uploaded data might be considered, especially if the system caters to user-generated datasets beyond satellite imagery.
- **Cloud Service Providers (Potential):** If the system leverages cloud computing for scalability or data storage (e.g., large satellite image archives), cloud service providers become external entities. Security considerations would be paramount when involving such entities.

Conclusion:

By employing a two-phase approach, we have identified key external entities that interact with or influence the automated debris glacier detection system. These entities encompass data providers, research institutions, and a range of end-users. Understanding their needs and interactions with the system will be crucial during design, interface development, and ensuring the system delivers value to its stakeholders.

1.2 Context Level Data Flow Diagram

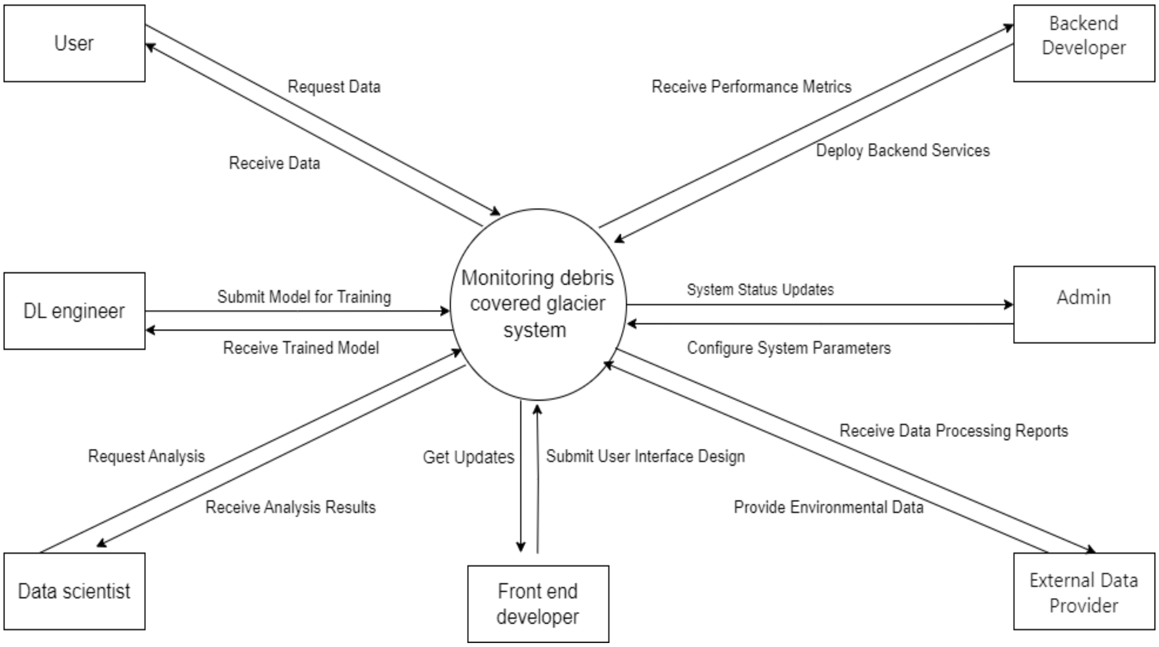


Figure 6: Context Level Data Flow Diagram

1.4 Capture "shall" Statements

Section	External Entity	"Shall" Statement	Description
User Management	End-User	Register with the system to create an account.	Establishes user account creation process.
User Management	System Administrator	Review and approve/reject registration requests.	Defines administrator role in user account management.
User Management	End-User	Log in to the system using their credentials.	Enables user authentication.
User Management	System	Allow End-Users to reset their passwords if forgotten.	Provides password recovery functionality.
User Management	End-User	View and update their profile information.	Allows user profile management.
Data Management	End-User	Upload geospatial data (satellite imagery) in supported formats.	Enables data submission by users.
Data Management	System	Validate the uploaded data format and notify the user of any errors.	Ensures data quality and compatibility.
Data Management	System	Store uploaded data securely.	Ensures data security.
Debris Cover Detection & Analysis	End-User (Optional)	Select pre-trained debris cover detection models (if applicable).	Allows user control over model selection (if available).
Debris Cover Detection & Analysis	System	Provide a user interface for selecting debris cover detection models.	Facilitates user interaction with model selection.
Debris Cover Detection & Analysis	System	Automatically process the uploaded data using the chosen model(s).	Defines the core functionality of debris cover detection.
Debris Cover Detection & Analysis	System	Display the analysis results within a reasonable timeframe.	Ensures system responsiveness and user experience.
Debris Cover Detection & Analysis	System	Present the results in a user-friendly format, including maps with debris cover extent highlighted.	Defines data visualization for clear communication of results.

Data Export & Reporting	End-User	Download the analysis results (maps, data) in various formats.	Enables users to leverage results for further work.
User Management	System Administrator	Manage user accounts (e.g., add/remove users).	Defines administrator control over user accounts.
User Management	End-User	Update their profile information (e.g., contact details, affiliation).	Allows user profile management.
Data Management	End-User	Upload additional data relevant to debris cover analysis (if the system allows).	Accommodates potential future functionalities for additional data types.
Debris Cover Detection & Analysis	System	Provide a user interface for selecting and applying appropriate debris cover detection models.	Facilitates user interaction with model selection.
Data Export & Reporting	End-User	Download the analysis results (maps, data) for further analysis or reporting.	Enables users to leverage results for further work.

1.5 Allocate Requirements

Para #	Initial Requirements	Use Case Name	Description
1.0	End-User "shall" register with the system to create an account.	UC_Register_End_User	User creates a new account (standard or privileged based on approval).
1.1	System Administrator "shall" review and approve/reject registration requests based on predefined criteria.	UC_Process_Registration	Administrator reviews and approves/rejects user registration requests.
1.2	End-User "shall" log in to the system using their credentials.	UC_Login	User authenticates by logging in.

1.3	System "shall" allow End-Users to reset their passwords if forgotten.	UC_Reset_Password	User retrieves a new password if forgotten.
1.4	End-User "shall" be able to view and update their profile information (e.g., contact details, affiliation).	UC_Manage_User_Profile	User accesses and updates their profile information.
2.1	End-User "shall" be able to upload geospatial data (satellite imagery) in supported formats.	UC_Upload_Data	User uploads satellite imagery for debris cover analysis.
2.2	System "shall" validate the uploaded data format and notify the user of any errors.	UC_Validate_Data	System checks the uploaded data format and informs the user of any issues.
2.3 (Optional)	End-User (Optional) "shall" be able to upload additional data relevant to debris cover analysis (if the system allows).	UC_Upload_Additional_Data (Optional)	User uploads additional data types relevant to debris cover analysis (if supported).
2.4	System "shall" securely store uploaded data following data privacy regulations.	UC_Secure_Data_Storage	System stores uploaded data securely following data privacy regulations.
3.1	End-User (Optional) "shall" select pre-trained debris cover detection models (if applicable).	UC_Select_Model (Optional)	User chooses a pre-trained model for debris cover detection (if available).

3.2	System "shall" provide a user interface for selecting and applying appropriate debris cover detection models.	UC_Provide_Model_Selection	System offers an interface for users to select appropriate debris cover detection models.
3.3	System "shall" automatically process the uploaded data using the chosen model(s).	UC_Process_Data	System automatically analyzes the uploaded data using the selected model(s).
3.4	System "shall" display the analysis results within a reasonable timeframe.	UC_Display_Results	System presents the analysis results to the user in a timely manner.
3.5	System "shall" present the results in a user-friendly format, including maps with debris cover extent highlighted and relevant statistics.	UC_Format_Results	System displays the results in a user-friendly format (maps, statistics) for clear communication.
3.6	System "shall" offer data visualization options (e.g., zoom, layer control) for further exploration of results.	UC_Explore_Results	System provides functionalities for users to explore the analysis results visually (e.g., zoom, layer control).

4.1	End-User "shall" be able to download the analysis results (maps, data) in various formats (e.g., GeoTIFF, CSV) for further analysis or reporting.	UC_Download_Results	User downloads the analysis results (maps, data) in various formats for further work.
4.2	End-User "shall" be able to generate custom reports incorporating analysis results and user annotations.	UC_Generate_Report	User creates reports combining analysis results and their own observations.
5.1	System "shall" provide a communication platform for users to share findings and collaborate on research.	UC_Enable_Collaboration (Optional)	System offers functionalities for users to share findings and collaborate (optional).
5.2	System "shall" implement access control mechanisms to ensure data privacy and security based on user roles.	UC_Implement_Access_Control	System enforces access control based on user roles to protect data privacy and security.
5.3	System Administrator "shall" monitor system performance and resource usage.	UC_Monitor_System_Performance	Administrator monitors system performance and resource usage.

1.6 Prioritize Requirements

Rank	Para #	Initial Requirements	Use Case ID	Use Case Name
Highest	1.0	End-User "shall" upload geospatial data (satellite imagery) for debris cover analysis.	UC_1	UC_Upload_Imagery
Highest	1.0	End-User "shall" register with the system to create an account (standard or privileged based on approval).	UC_2	UC_Register_End_User
Highest	2.0	End-User "shall" select a payment method (cash or credit card) for the analysis.	UC_3	UC_Select_Payment_Method
Highest	2.0	System "will" generate an invoice and confirmation receipt upon successful order submission.	UC_4	UC_Generate_Invoice_Receipt
Medium	2.0	Both registered and privileged users "shall" be able to submit debris cover analysis orders.	UC_5	UC_Submit_Analysis_Order (privileged)
Medium	1.1	System Administrator "shall" review and approve/reject user registration requests based on predefined criteria.	UC_6	UC_Process_Registration

Medium	3.1 (Optional)	End-User (Optional) "shall" select pre-trained debris cover detection models (if applicable).	UC_7	UC_Select_Model (Optional)
Medium	3.2 (Optional)	System "shall" provide a user interface for selecting and applying appropriate debris cover detection models (if applicable).	UC_8	UC_Provide_Model_Selection (Optional)
Medium	3.3	System "shall" automatically process the uploaded imagery using the chosen model(s).	UC_9	UC_Process_Imagery
Medium	3.4	System "shall" display the analysis results within a reasonable timeframe.	UC_10	UC_Display_Results
Medium	3.5	System "shall" present the results in a user-friendly format, including maps with debris cover extent highlighted and relevant statistics.	UC_11	UC_Format_Results
Medium	3.6	System "shall" offer data visualization options (e.g., zoom, layer control) for further exploration of results.	UC_12	UC_Explore_Results

Medium	4.1	End-User "shall" be able to download the analysis results (maps, data) in various formats (e.g., GeoTIFF, CSV) for further analysis or reporting.	UC_13	UC_Download_Results
Medium	4.2	End-User "shall" be able to generate custom reports incorporating analysis results and user annotations.	UC_14	UC_Generate_Report
Medium	2.4	System "shall" securely store uploaded data following data privacy regulations.	UC_15	UC_Secure_Data_Storage
Medium	1.0	System "shall" allow End-Users to reset their passwords if forgotten.	UC_16	UC_Reset_Password
Medium	1.2	End-User "shall" log in to the system using their credentials.	UC_17	UC_Login
Medium	1.4	End-User "shall" be able to view and update their profile information (e.g., contact details, affiliation).	UC_18	UC_Manage_User_Profile

Medium	2.3 (Optional)	End-User (Optional) "shall" be able to upload additional data relevant to debris cover analysis (if the system allows).	UC_19	UC_Upload_Additional_Data (Optional)
Lowest	5.1 (Optional)	System "shall" provide a communication platform for users to share findings and collaborate on research (optional).	UC_20	UC_Enable_Collaboration (Optional)
Lowest	5.2	System "shall" implement access control mechanisms to ensure data privacy and security based on user roles.	UC_21	UC_Implement_Access_Control
Lowest	5.3	System Administrator "shall" monitor system performance and resource usage.	UC_22	UC_Monitor_System_Performance
Lowest	3.0 (Optional)	Corresponding administrator "shall" view his Action List containing different actions, and correspondingly process these pending actions (optional).	UC_23	UC_View_

1.6 Requirements Trace-ability Matrix

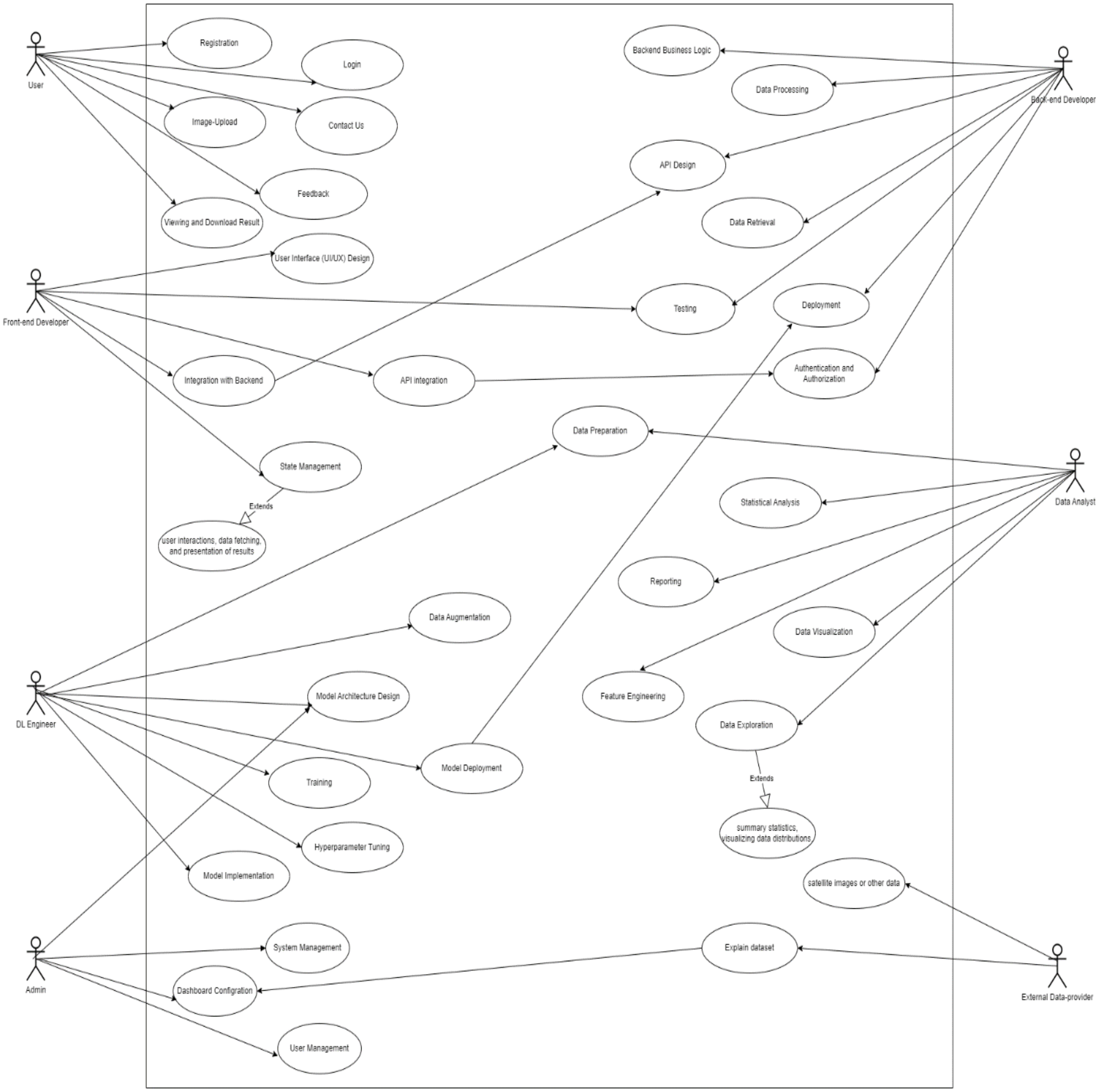
Sr#	Para #	System Specification Text (Ice Age)	Build	Use Case Name	Category
1	1.0	End-User "shall" upload geospatial data (satellite imagery) for glacier debris cover analysis.	B1	UC_Upload_Imagery	Business
2	1.0	End-User "shall" register with the system to create an account (standard or privileged based on approval).	B1	UC_Register_End_User	Business
3	1.0	System "shall" provide options for standard and privileged user registration.	B1	UC_Register_Standard_User	Business
3	1.0		B1	UC_Register_Privileged_User (Optional)	Business
4	N/A	N/A	B1	UC_Review_Analysis_Request (Optional)	Business
4	N/A	N/A	B1	UC_Approve_Analysis_Request	Business
4	N/A	N/A	B1	UC_Reject_Analysis_Request	Business
5	1.0	End-User "shall" log in to the system using their credentials.	B1	UC_Login	Business
6	1.0	System "shall" allow End-Users to reset their passwords if forgotten.	B1	UC_Reset_Password	Business

7	1.0	System "shall" update user information based on their requests (details below).	B1	UC_Update_User_Profile	Business
7			B1	UC_Change_Personal_Details	Business
7			B1	UC_Request_Account_Upgrade (Optional)	Business
7			B1	UC_Change_Payment_Method	Business
8	1.0	End-User "shall" be able to view and update their profile information.	B1	UC_Manage_User_Profile	Business
9	(redundant)	System "shall" search any customer details	N/A	(removed)	N/A
10	2.1 (Optional)	End-User (Optional) "shall" select pre-trained glacier debris detection models (if applicable).	B1	UC_Select_Model (Optional)	Business
11	2.2 (Optional)	System "shall" provide a user interface for selecting and applying appropriate glacier debris detection models (if applicable).	B1	UC_Provide_Model_Selection (Optional)	Business
12	3.1	System "shall" automatically process the uploaded imagery using the chosen model(s).	B1	UC_Process_Imagery	Business

13	3.2	System "shall" display the analysis results within a reasonable timeframe.	B1	UC_Display_Results	Business
14	3.3	System "shall" present the results in a user-friendly format, including maps with glacier debris extent highlighted and relevant statistics (e.g., area, volume).	B1	UC_Format_Results	Business
15	3.4	System "shall" offer data visualization options (e.g., zoom, layer control) for further exploration of results (e.g., debris thickness variations).	B1	UC_Explore_Results	Business
16	4.1	End-User "shall" be able to download the analysis results (maps, data) in various formats (e.g., GeoTIFF, CSV) for further analysis or reporting.	B1	UC_Download_Results	Business

17	4.2	End-User "shall" be able to generate custom reports incorporating analysis results and user annotations.	B1	UC_Generate_Report	Business

1.9 High Level Usecase Diagram


User
Registration
Login
Image-Upload
Contact Us
Feedback
Viewing and Download Result
Front-end Developer
User Interface (UI/UX) Design
Testing
Integration with Backend
API integration
State Management
Extends
user interactions, data fetching, and presentation of results
Backend Business Logic
Data Processing
Back-end Developer
API Design
Data Retrieval
Deployment
Authentication and Authorization
Data Preparation
Data Analyst
Statistical Analysis
Reporting
Data Visualization
Feature Engineering
Data Exploration
Extends
summary statistics, visualizing data distributions
DL Engineer
Data Augmentation
Model Architecture Design
Model Deployment
Training
Hyperparameter Tuning
Model Implementation
satellite images or other data
Admin
System Management
Explain dataset
External Data-provider
Dashboard Configration
User Management