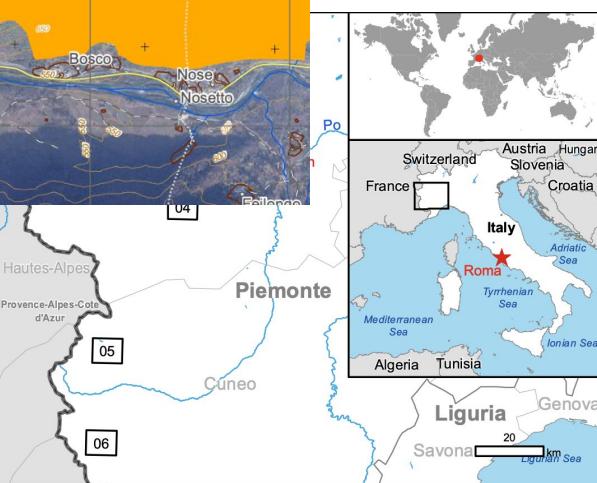


Multi-Task Learning for Fire Ignition Maps

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Yousef Fayyaz: s341999



The Problem

- Wildfires are a growing environmental and socio-economic concern, driven by climate change
- Traditional remote sensing methods are **reactive**, relying on mapping burned areas **after** the event.
- This limits the ability of emergency services to allocate resources effectively during the critical initial stages of a fire." as a problem say this better

Solutiostn:

- A deep learning solution for PROACTIVE PRE-FIRE PREDICTION to enhance emergency response and resource allocation.
- A MULTI-MODAL NEURAL NETWORK that fuses satellite, weather, and terrain data for ACCURATE SPREAD FORECASTING.
- CRITICAL DECISION-SUPPORT for emergency services, shifting from REACTIVE mapping to PROACTIVE planning.



VALUE PROPOSITION

Investigating proactive wildfire prediction to mitigate environmental damage and improving emergency response, and strengthening regional climate resilience.



Environmental Impact

Proactive prediction enables faster response, helping to reduce the total area burned and subsequent CO2 emissions.



Response Efficiency

Early risk assessment helps Civil Protection allocate resources effectively, protecting communities and infrastructure.



Innovation & Scalability

The developed AI framework can be applied to other regions and serves as a reproducible template for future crisis-AI projects.

Objectives & Benefits

Objective 1: Data Harmonization

Create a unified, multimodal dataset by integrating 7 heterogeneous sources (e.g., Sentinel-2, ERA5, DEM, Roads, Land Cover)

Benefit: A unique, analysis-ready dataset for wildfire modeling and research.

Objective 3: Develop Novel Architecture

Design and train the multi-modal, multi-task deep learning architecture using a shared encoder, fusion blocks, and multiple prediction heads.

Benefit: Achieves higher accuracy by learning richer representations through auxiliary tasks (e.g., Land Cover segmentation).

Objective 2: Establish Baseline

Implement and evaluate a baseline single-task segmentation model (e.g., U-Net) to define benchmark performance for burned-area prediction.

Benefit: Provides a clear, quantitative metric to measure the value of our new model.

Objective 4: Evaluate & Deliver

Rigorously evaluate the model against the baseline using IoU and deliver open-source code and documentation.

Benefit: Assess the model against the baseline using IoU and additional metrics, and deliver complete open-source code and documentation.

Our Multimodal Data Sources

Our model's strength comes from fusing seven distinct data types, each processed by a dedicated encoder.



Sentinel-2

Multispectral Imagery



Landsat

Historical Imagery



Copernicus DEM

Topography & Slope



Copernicus ERA5

Weather (Temp, Wind)



Piedmont Roads

Human Proximity



Dynamic World

Land Cover / Fuel Type



Ignition Points

Fire Start Location

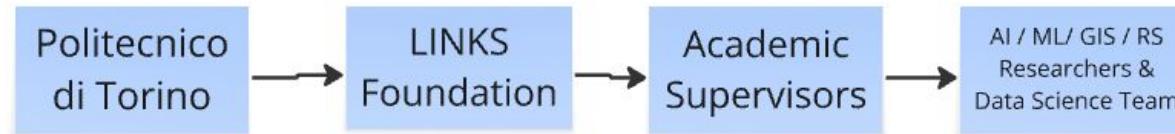


Burned Area Mask

Ground Truth (Target)

Stakeholder Analysis: Key Actors

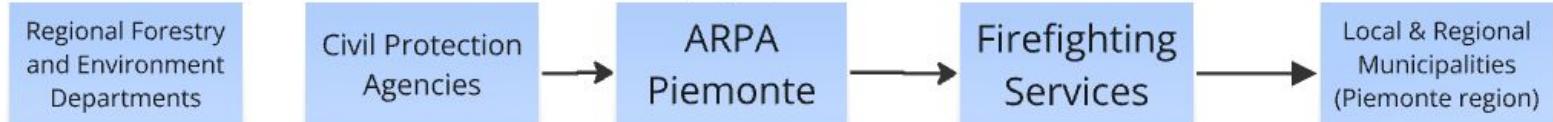
Research & Project Team:



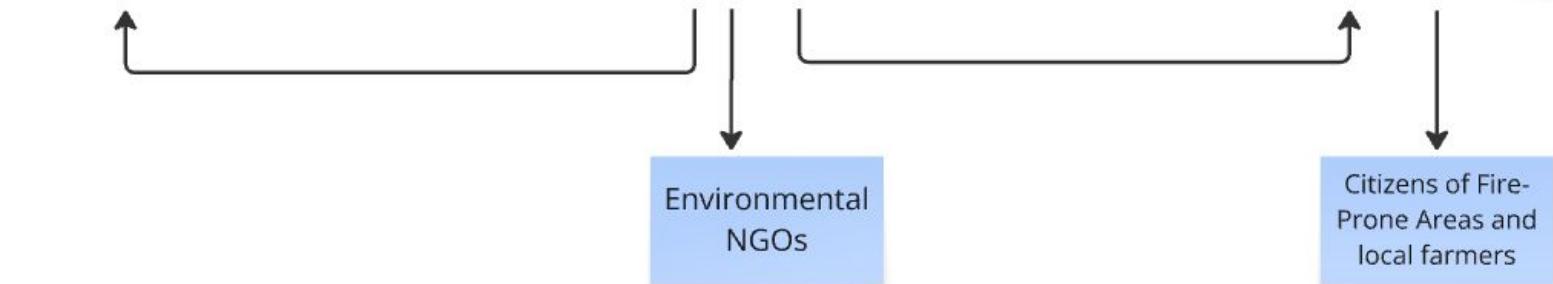
Data & Policy Providers (Supranational):



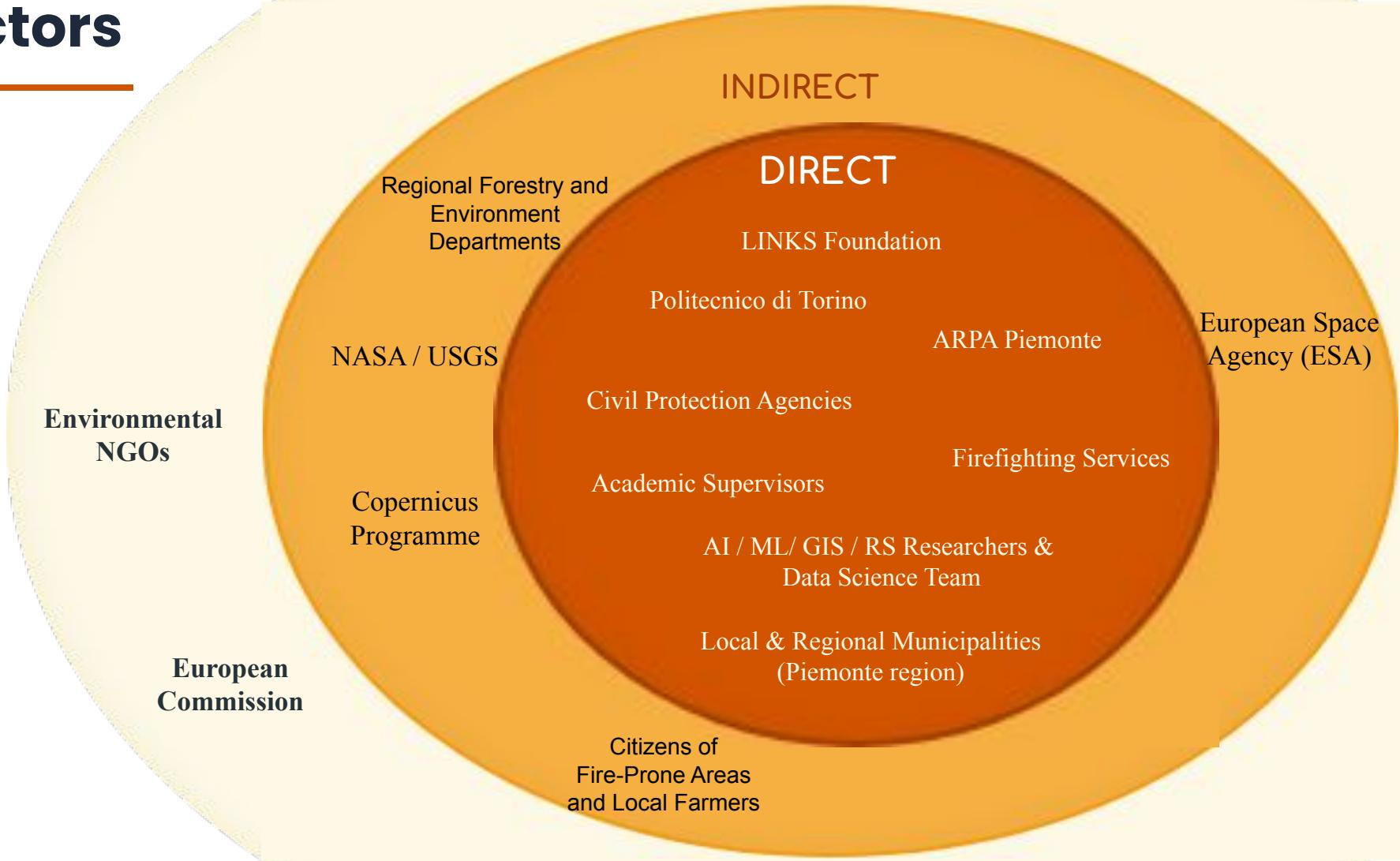
Regional & Civil Actors:



Public/End-Users:



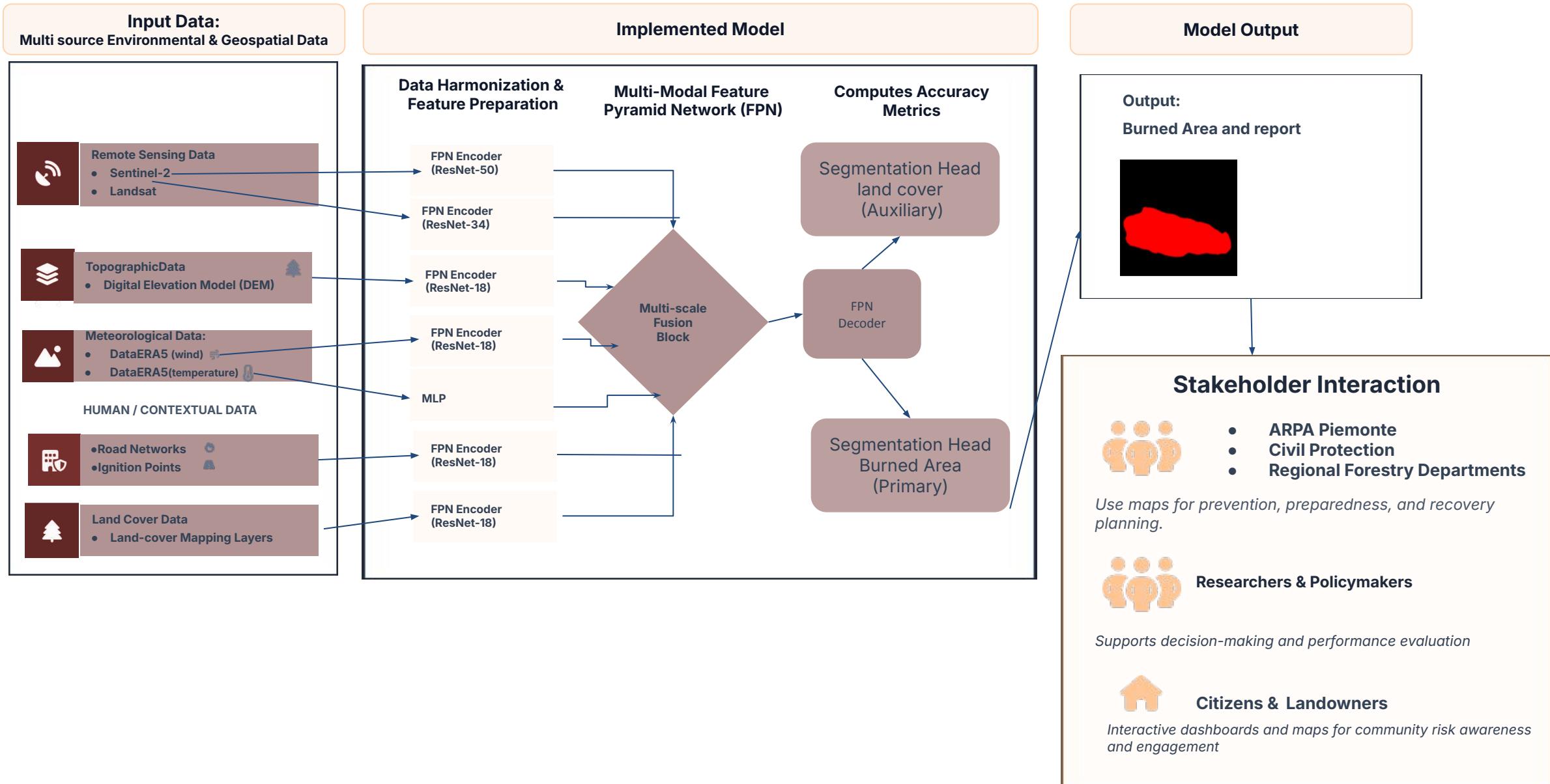
Stakeholder Analysis: Key Actors



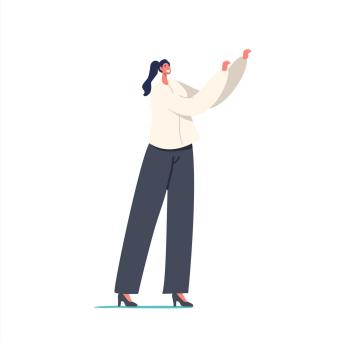
Interest-Influence Matrix

	Low Interest	High Interest
High Power	<ul style="list-style-type: none">• European Commission• ESA & Copernicus• NASA / USGS	<ul style="list-style-type: none">• LINKS Foundation• Research Team (AI/ML)• ARPA Piemonte• Civil Protection Agencies• Firefighting Services• Local & Regional Municipalities (Piemonte region)
Low Power	<ul style="list-style-type: none">• Similar Research Projects• Non-critical Institutions	<ul style="list-style-type: none">• Citizens (Fire-Prone)• Local Farmers• Environmental NGOs• Regional Forestry & Environment Departments• Research Personnel involved in wildfire studies (external)

Project Design: Functional Diagram



User Personas (1/3)



Francesco Rossi

Role: Regional Civil Protection
Operations Coordinator

Pain Points & Frustrations

- 👉 Delays in receiving field updates and satellite images.
- 👉 Lack of predictive capability; all current tools are reactive.
- 👉 Overwhelmed by complex technical data formats.
- 👉 Uncertainty in prioritizing multiple simultaneous fires.

Goals & Needs

- 👉 Obtain rapid, reliable burned-area predictions *before* dispatching resources.
- 👉 Reduce decision time from hours to minutes.
- 👉 Needs a web dashboard with confidence scores and exportable GIS layers.

User Personas (2/3)



Elena Bianchi

Role: Provincial Fire Brigade
Commander

Pain Points & Frustrations

- 👉 Limited connectivity and complex tools in remote/stressful zones.
- 👉 Satellite data is often too delayed to be tactical.
- 👉 Insufficient visibility of terrain and fire spread evolution.
- 👉 High pressure for rapid decisions without enough data.

Goals & Needs

- 👉 Gain situational awareness in real-time (fire direction, wind, slope).
- 👉 Deploy teams and vehicles efficiently and safely.
- 👉 Needs a mobile-accessible, simplified fire spread map with frequent updates and clear risk zones.

User Personas (3/3)



Marco Conti

Role: Environmental Analyst (ARPA
Piemonte)

Pain Points & Frustrations

- 👉 Manual and time-consuming data preprocessing for reports.
- 👉 Inconsistent data sources and metadata from different agencies.
- 👉 Lack of standardized evaluation metrics for predictive models.
- 👉 Difficulty accessing operational data from Civil Protection.

Goals & Needs

- 👉 Improve accuracy and automation of burned-area mapping.
- 👉 Validate and benchmark new predictive models for research.
- 👉 Needs validated models, statistical performance reports (IoU), and GIS datasets for policy reports.

User Stories

Francesco (Civil Protection)

"As a Civil Protection coordinator, I want fast and reliable burned-area predictions, so that I can allocate resources quickly and reduce response time."

"As a coordinator, I want a confidence score for the prediction, so that I can understand the model's certainty before committing a helicopter."

Elena (Firefighter Chief)

"As a field commander, I want simple, mobile-friendly fire-spread maps, so that I can plan safe containment strategies on-site."

"As a commander, I want to see the predicted spread overlaid on terrain, so that I can identify dangerous slopes or gullies for my crew."

Marco (Environmental Analyst)

"As an Environmental Analyst, I want to automate land-cover and environmental data processing, so that I can validate model predictions faster."

"As an Analyst, I want access to the model's performance metrics (IoU), so that I can write accurate environmental impact reports and publish research."

Work Breakdown Structure (WBS)

WP No.	Work Package Title	Lead	Tasks	PM
1	Project Management & Familiarization	Parastoo	Define objectives, project plan, literature review, checkpoint prep.	1.0
2	Data Preparation & Exploration	Yousef	Collect, clean, preprocess, and align all 7 data sources (Sentinel-2, Landsat, DEM, ERA5, etc.). Create data loader.	2.5
3	Baseline Model Implementation	Yousef	Implement a standard single-task U-Net/DeepLab. Train and evaluate on the dataset to establish a benchmark IoU.	1.5
4	Multi-Task Model Development	Yousef	Build multi-encoder architecture. Implement multi-scale fusion blocks. Add auxiliary (Land Cover) head. Implement multi-loss function.	3.0
5	Evaluation & Comparison	Parastoo	Train the new MT-model. Perform hyperparameter tuning. Compare results vs. baseline. Analyze feature importance.	2.0
6	Documentation & Communication	Parastoo	Prepare final report, slides, and presentation. Clean code for GitHub repository.	1.0

Management Plan: GANTT Chart (Tasks)

WBS	Task	Assigned To	Start	End	Status
1.0	Project Management	Parastoo	28/10/25	13/01/26	Ongoing
1.1	Define Project Objectives	Yousef	28/10/25	31/10/25	Done
1.2	Project Design & Literature Review	Parastoo	01/11/25	09/11/25	Done
1.3	Develop Project Plan (WBS, GANTT)	Team	05/11/25	12/11/25	Done
1.4	Checkpoint #1 Presentation	Team	13/11/25	17/11/25	Done
2.0	Data Preparation	Parastoo	01/11/25	06/12/25	Ongoing
2.1	Collect & Ingest All 7 Data Sources	Yousef	01/11/25	21/11/25	Ongoing
2.2	Data Preprocessing & Alignment	Parastoo	18/11/25	01/12/25	Todo
2.3	Develop PyTorch DataLoaders	Parastoo	02/12/25	06/12/25	Todo

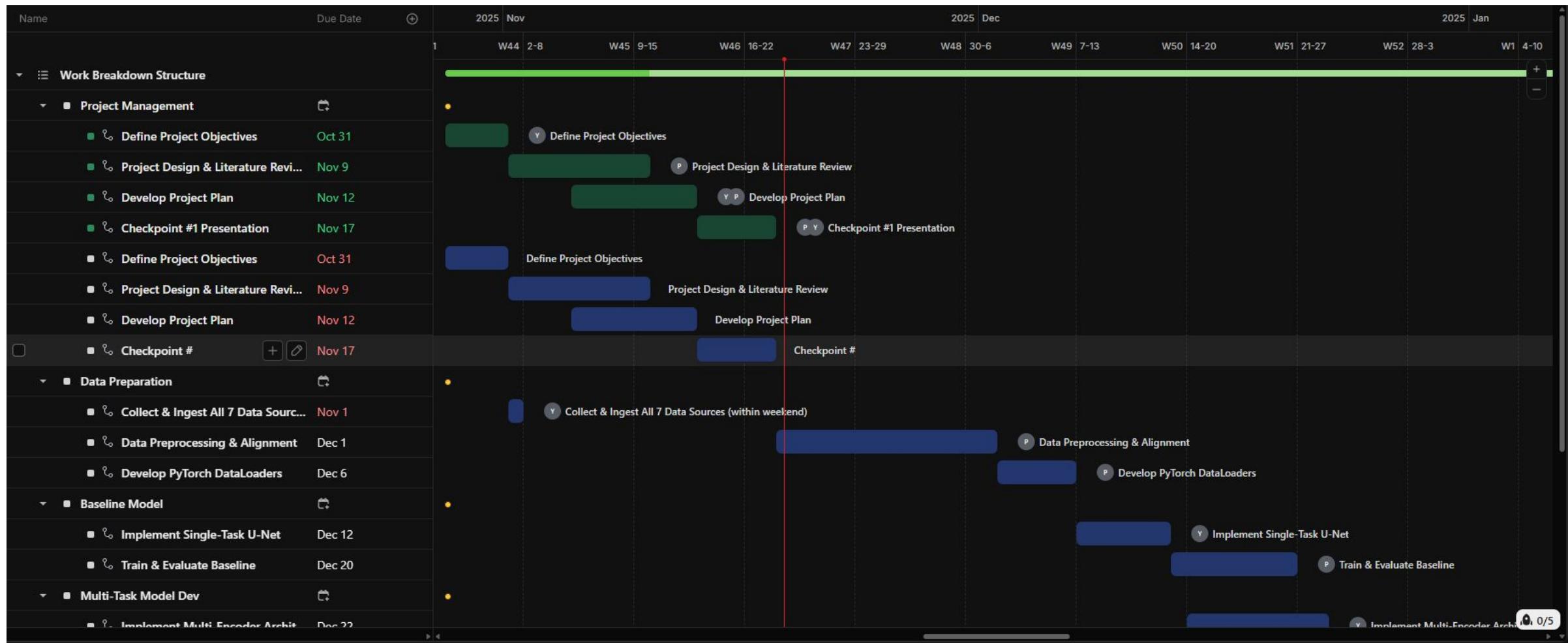
Management Plan: GANTT Chart (Tasks)

WBS	Task	Assigned To	Start	End	Status
3.0	Baseline Model	Yousef	07/12/25	20/12/25	Todo
3.1	Implement Single-Task U-Net	Yousef	07/12/25	12/12/25	Todo
3.2	Train & Evaluate Baseline	Parastoo	13/12/25	20/12/25	Todo
4.0	Multi-Task Model Dev	Yousef	14/12/25	07/01/26	Todo
4.1	Implement Multi-Encoder Arch	Yousef	14/12/25	22/12/25	Todo
4.2	Implement Fusion Blocks & Aux Head	Yousef	23/12/25	02/01/26	Todo
5.0	Evaluation & Comparison	Parastoo	03/01/26	12/01/26	Todo
5.1	Train & Tune MT-Model	Yousef	03/01/26	09/01/26	Todo
5.2	Compare Models & Analyze Results	Parastoo	10/01/26	12/01/26	Todo
6.0	Documentation	parastoo	05/01/26	16/01/26	Todo
6.1	Prepare Final Report & Slides	Team	05/01/26	14/01/26	Todo
6.2	Clean Code & Publish to GitHub	Parastoo	10/01/26	16/01/26	Todo

Management Plan: GANTT Chart (Visual Timeline)



Management Plan: GANTT Chart (ClickUp app)





Thank you

Questions?

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