

Fossil Foresight Design Project Description Final

Summary

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Fossil Foresight is a scientific decision-support system designed to improve fossil discovery and excavation planning through data-driven prediction and structured safety guidance. The system integrates geological datasets, satellite imagery, historical fossil records, and machine learning models to identify high-probability fossil sites and generate excavation plans that reduce structural risk, environmental disruption, and operational cost. The project addresses the limitations of current fossil discovery workflows, which rely heavily on manual scouting and expert intuition, resulting in slow, resource-intensive processes with low discovery success rates.

The project goals focus on measurable improvements in prediction accuracy, time efficiency, safety outcomes, environmental protection, and operational cost reduction. Success criteria include a 25% improvement in correct fossil site identification, a 40% reduction in scouting time, a 20% reduction in excavation-related safety incidents, a 30% decrease in unnecessary land disturbance, and a 15% reduction in operational costs. These metrics ensure that the system delivers validated improvements over traditional methods.

The scope of the work includes analyzing existing fossil discovery processes, integrating multi-source datasets, and supporting researchers and field workers through predictive modeling and excavation planning. The system provides GIS visualization, interpretable prediction outputs, and structured excavation plans with environmental and structural risk indicators. It does not perform physical excavation, issue permits, or analyze fossils, but instead supports scientific and field teams with accurate, actionable insights. Work partitioning divides responsibilities among data providers, system administrators, researchers, and field workers.

The requirements specification defines 63 functional and nonfunctional requirements across performance, dependability, maintainability, security, usability, accessibility, documentation, training, operational, cultural, political, and legal categories. These requirements ensure that the system predicts fossil sites accurately, supports safe excavation planning, integrates with GIS and scientific datasets, operates reliably in both laboratory and field environments, protects sensitive research data, and complies with environmental and regulatory standards. Each requirement includes measurable fit criteria and acceptance tests.

The final system design decomposes the system into seven subsystems: User Interface, Prediction, Planning, Data Ingestion, Field Sync, Repository, and External Integration. Each subsystem contains clearly defined classes with specific responsibilities and interfaces. The User Interface subsystem manages researcher workflows, field operations, and dataset uploads. The Prediction subsystem handles feature extraction, model execution, and probability scoring. The

Planning subsystem generates excavation plans using prediction results and hazard data. The Data Ingestion subsystem validates and processes uploaded datasets. The Field Sync subsystem supports offline access and synchronization of field observations. The Repository subsystem manages all persistent data. The External Integration subsystem retrieves weather and hazard information from outside services.

Object design details the responsibilities and public methods of each class, including PredictionEngine, PlanningController, IngestionController, SyncController, RepositoryManager, and the various data entities. The design emphasizes modularity, clear interfaces, and separation of concerns. The system architecture supports cloud deployment, GIS integration, offline field operation, and external API communication.

Project issues identified include scheduling challenges, role ambiguity, and the need for clearer task tracking. Off-the-shelf solutions such as GIS libraries, machine learning frameworks, and cloud hosting platforms were evaluated and incorporated where appropriate. Migration considerations include dataset translation, user onboarding, and integration with existing research workflows.

The risk analysis identifies several potential risks, including low-quality datasets, prediction inaccuracies, external API failures, offline synchronization issues, repository scalability concerns, and usability challenges for field users. Each risk is assigned a probability and considered in terms of its impact on schedule and performance. Cost estimates based on deliverables, function point analysis, and development effort place the total project cost between \$18,000 and \$30,000, with an estimated development timeline of 14 to 22 weeks.

The waiting room records deferred features such as automated permit-checking, drone imagery ingestion, excavation simulation, multi-user collaboration, and augmented reality overlays. These features are not part of the current release but may be considered for future versions. Ideas for solutions include using Python-based machine learning frameworks, React for the user interface, GIS libraries for mapping, Docker for deployment, and automated testing tools for validation.

The project retrospective reflects on the effectiveness of communication through Discord, the challenges of scheduling and role assignment, and the need for improved task tracking. Despite these challenges, the team produced a complete requirements specification, system design, and final report that met the goals of the project.

Overall, Fossil Foresight provides a unified, scientifically grounded platform that enhances fossil discovery accuracy, improves excavation safety, reduces environmental impact, and supports efficient field operations. The final report documents the system's requirements, design, risks, costs, and future enhancements, forming a strong foundation for future implementation.

