Autonomous Ultrasound AI for Extreme Environments

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NASA

Background

Humans in extreme environments, from space to deep-sea, polar, and disaster zones, face major medical and diagnostic challenges due to isolation and limited resources. In microgravity, fluid shifts and tissue stress can hide internal injuries. Ultrasound is the only safe, portable imaging tool for these settings, but current AI-assisted systems depend on cloud connectivity, which isn't viable off-world or offline.
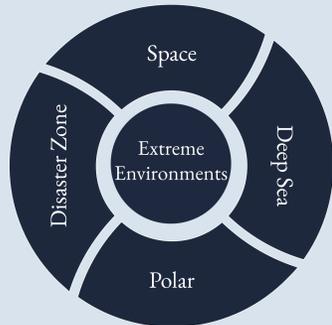
A self-contained, low-power ultrasound device capable of offline image analysis could detect internal bleeding and support autonomous medical care anywhere humans operate.

(Diagram: Extreme Environments — Space, Deep Sea, Polar, Disaster Zone)

Mission Statement

Atlas Sonography leverages **innovative AI software** to make critical care possible anywhere. Our technology empowers responders, explorers, and clinicians with **portable, autonomous diagnostic capability** on any ultrasound device, enabling accurate medical insight even in the **most isolated environments**.

Project Timeline

01 **Concept Framing** - Defined problem scope with NASA and Mayo mentors; early research on space imaging constraints. Completed concept mapping and competitive benchmarking.
Time frame: August - September 2025

02 **Foundational Learning** - Team learned ultrasound workflows, FAST protocol, and initial image preprocessing. Completed Needs Metric Table and House of Quality.
Time frame: October 2025

03 **Model Exploration** - Built small prototypes for image analysis and model confidence. Completed initial technical models and product architecture.
Time frame: November - December 2025

04 **Building Model** - Dataset collection and training/building algorithm. Will complete initial prototype of machine learning algorithm, gather datasets, complete app architecture.
Time frame: January - February 2026
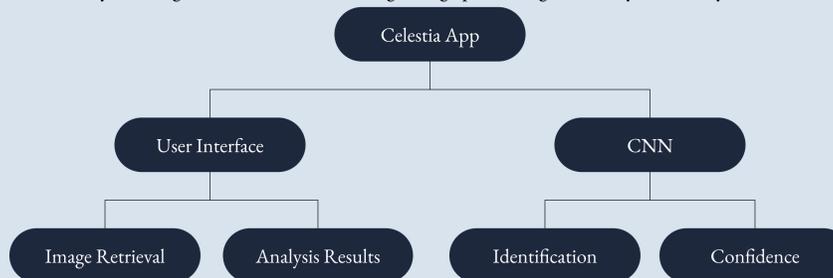
05 **Development and Validation** - Integration of all project parts; Validation testing on a phantom. Will finish all four algorithm quadrants, train all algorithms, and integrate into app structure.
Time frame: February - May 2026

Design Inputs

| Category	Input	Source / Rationale
Clinical Function	Detect abnormal FAST scans and possible free-fluid.	Mayo clinician input.
Operational	Must function offline in microgravity.	NASA ExMC standards.
Power	≤1 W continuous draw for 2+ hrs.	Mission hardware limit.
Thermal	Surface temp ≤40 °C during use.	ISO 80601-2-37.
Data	Compress & store scans locally (≤5% loss).	No cloud access in orbit.
User Interface	Display "Normal" or "Abnormal" clearly.	Human factors review.
Durability	Portable, <2 kg, shock resistant.	Space environment.

Device Concept

Android-based ultrasound system combining probe + tablet for fully offline AI diagnostics. Powered by six integrated modules that manage image processing, reliability, and safety:

```
                 Celestia App
              /              \
      User Interface          CNN
       /        \            /      \
Image     Analysis    Identification  Confidence
Retrieval  Results
```

Product Architecture

This is an example output from our software. The base image is an Ultrasound from the Right Upper Quadrant (RUQ). The quadrant should show the liver, kidney, and if there is fluid it will exist in Morison's Pouch. The output from our software will outline/highlight the organs in blue and the free fluid in red.
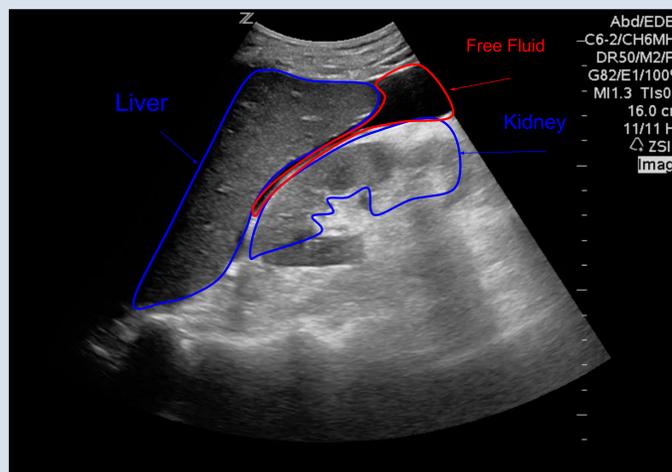
Design for Manufacturing

Part	Price
Tablet and Ultrasound Probe	$2k - $3k
AI Development and Dataset Preparation	$40k - $60k
Testing, Validation, and Regulatory	$20k - $40k
Total Cost	**$60k - $100k**

Final Specifications

Performance Area	Specification	Metric / Verification
Diagnostic Accuracy	CNN distinguishes normal vs. abnormal scans.	≥ 90% accuracy.
Reliability	Confidence Algorithm ensures valid outputs.	$C_t \geq 0.95$.
Latency	Real-time inference feedback.	≤ 3 s per frame.
Power	Low-power embedded AI.	≤ 1 W continuous.
Thermal Safety	Maintains safe touch temperature.	≤ 40 °C.
Storage	Efficient compression & recall.	≤ 5% data loss.
Physical Design	Lightweight modular device.	< 2 kg total.

Future Work

AI Refinement
→ Retrain CNN and confidence models with larger FAST ultrasound datasets.

System Integration
→ Combine data compression, segmentation, and power control into one optimized software build.

Prototype Validation
→ Conduct bench and environmental testing to verify reliability and thermal safety.

Clinical Collaboration
→ Review outputs with Mayo physicians for diagnostic accuracy and workflow usability.

Regulatory & Deployment Prep
→ Initiate FDA Class II alignment, ISO 14971 risk documentation, and field simulation testing.

Acknowledgements

Scan here for more information

ATLAS SONOGRAPHY