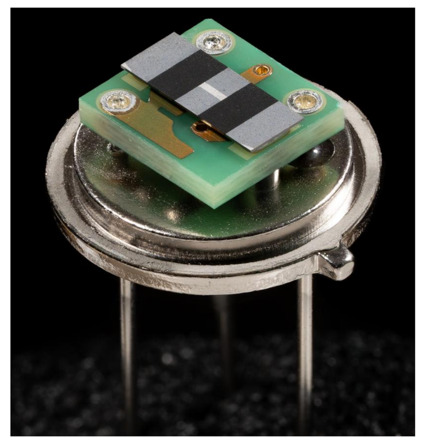
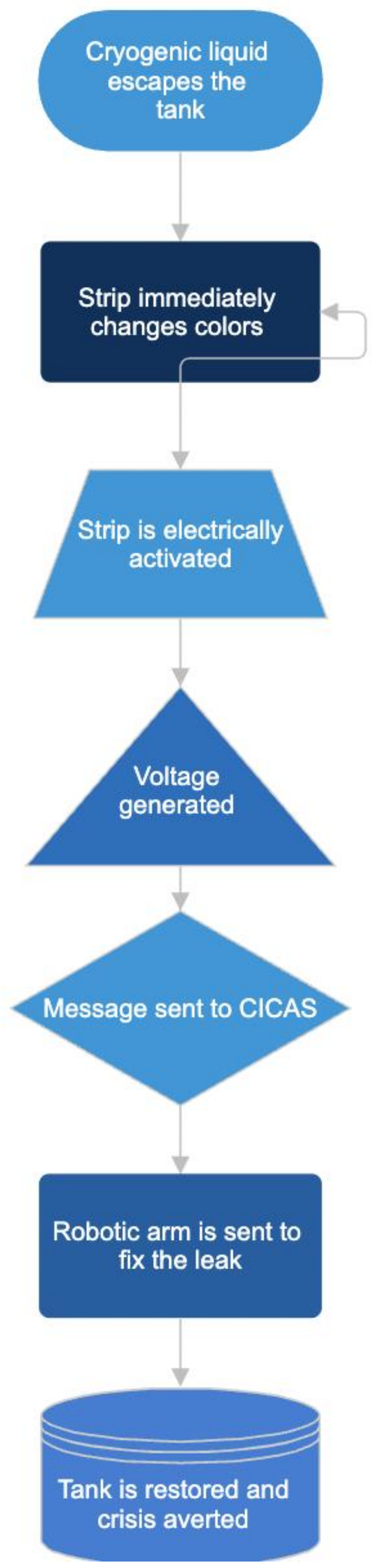
Cryogenic Fuel and Transfer: The Human Interface – Monitoring and Mitigating Risks

The implementation of a Cryogenic Detection Strip—a visual and electronic monitoring system to identify and signal leaks in preflight conditions and during long-duration missions.

Process Summary

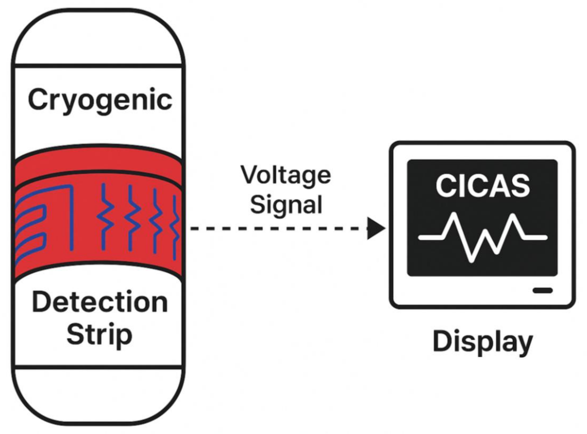




When cryogenic liquid escapes, it turns into a gas with extremely low hazardous temperatures.

Using thermochromic materials the strip will visually change colors from red to blue. Red for temperate and Blue for the extremely low temperatures being created from the leak.

The strip also utilizes pyroelectric sensors or thermocouples. The rapid cooling is detected by the sensors, generating a voltage that is processed through a small electronic circuit embedded within the strip.



Sending the Signal

C I C A S

Cryogenic Indicating Crew Alert System

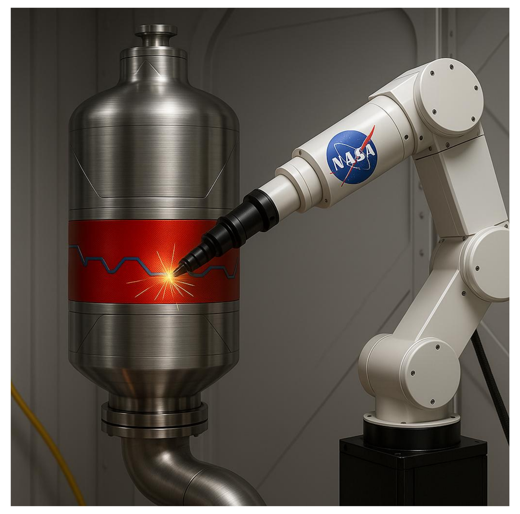
- Based on the CRJ-700 (Bombardier regional aircraft) Engine Indicating Crew Alerting System (EICAS)
- Uses a Super Magnetic Energy Storage (SMES) system
- A high temperature superconductor is placed in the cryogenic environment to store electricity

- A power conditioning system will regulate electrical flow into the CICAS system and serve as a voltage regulator linked to the cryogenic sensors
- A display graphic of the area indicates leak locations allowing the crew to monitor and repair leakage related to HLS cryogenic fuel tanks

Repairing the Damage

Using Artificial Intelligence software, a robotic arm will take the data from the indications from the pyroelectric strips and seal them immediately.

The arm will use materials such as, Kapton tape, which can withstand extremely low temperatures, or medical-grade tape with epoxy resin on top to seal the leaks.



Timeline and Budget

Year	2025	2026	2027	2028	2029
Phase	Exploratory	Functional		Implementation & Operation	
Cryogenic Safe Planning	Engineering analysis of effectiveness of the Cryogenic Detection Strip and material validation. Testing of SMEC and CICAS Function with Detection Strips.	Manufacturing process and Flight Demonstration – Deployment on small-scale missions for real-world validation. Integrating CICAS sytem into the already functioning aircraft system.		Full-Scale Integration – Implementation into NASA's Human Landing System (HLS) and commercial lunar cryogenic vehicles	

Item	Quantity	Cost/Unit	Total Cost	Vendor
Polyimide Film	8,550 ft	$0.50/ft	$4,275	APICAL®
Polyvinylidene Fluoride	8,550 ft	$10.00/ft	$85,500	Arkema Global
Thin Film Thermocouples	8,550 ft	$2.00/ft	$17,100	Dwyer Instruments
Circuit Board	8,550 ft	$5.00/ft	$42,750	FlexPCB
EICAS Display	1	$15,000.00	$15,000.00	L3Harris
NanoPower P60 Power System	1	$15,000.00	$15,000.00	GomSpace
SMES Unit	1	$1,000,000.00	$1,000,000.00	American Superconductor
Total			$1,179,625.00	

Why is it Important?

Currently cryogenic chambers do not have the ability to pinpoint the exact location of a cryogenic leak in real time. This forces crews to waste critical time investigating or reacting with broad, imprecise measures. The strip reduces mission risk without human error and limits crew exposure to danger.

Knowing exactly where the problem is can make the difference between success and catastrophe, adding a valuable safety component and core piece to NASA's Human Lander System.

Team Members and Advisors

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Motto and Labeling

CRYOGENIC
SAFE