



OceanGate Titan Implosion - 5 fatalities

Location of Incident	OceanGate, North Atlantic
Date of Incident	June 19, 2023
Date of Final Report	DRAFT September 24, 2024

Cause Mapping®

- 1. Problem
- 2. Analysis
- 3. Solutions



SUMMARY FILE - Contents

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Incident Description

For a more detailed sequence of events, see Timeline.

On June 18, 2023, Titan, a submersible operated by the American tourism and expeditions company OceanGate, imploded during an expedition to view the wreck of the Titanic in the North Atlantic Ocean off the coast of Newfoundland, Canada.

Communication between Titan and its mother ship, MV Polar Prince, was lost 1 hour and 45 minutes into the dive. Authorities were alerted when it failed to resurface at the scheduled time later that day. After the submersible had been missing for four days, a remotely operated underwater vehicle (ROV) discovered a debris field containing parts of Titan about 500 meters (1,600 ft) from the bow of the Titanic. The search area was determined based on the United States Navy's (USN) detection of an acoustic signature consistent with an implosion, which occurred around the same time the Titan lost communication. This suggested the submersible's pressure hull likely failed during its descent, resulting in the immediate deaths of all five occupants.

The search and rescue operation was performed by an international team organized by the United States Coast Guard (USCG), USN, and Canadian Coast Guard. Support was provided by aircraft from the Royal Canadian Air Force, United States Air National Guard, and a Royal Canadian Navy ship as well as several commercial and research vessels and ROVs.

1. Problem Outline

		OceanGate Titan Implosion - 5 fatalities	
What When	Problem(s)	5 people killed, implosion of Titan submersible	
	Date	June 19, 2023	
	Time	9:45 AM	
Where	Different, unique, abnormal	4th voyage down to Titanic, ~12500 ft depth, lost communication 1:45 into voyage at 3346 meters (10,977 ft)	
	Facility, site, location	OceanGate, North Atlantic	
	Unit, area	RMS Titanic Wreckage (North Atlantic)	
	Equipment, tools	Titan Experimental Submersible, Polar Prince, Launch and Recovery System (LARS)	
	Task(s), operation being done	Dive down to titanic	
Impact to Goals		<i>Quantify the specific negative consequence to each one below</i>	
	Safety	Loss of 5 crew	
	Environmental	Debris on seabed	
	Customer	OceanGate ceases to operate, multiple customers lost deposit of dive	
	Production, Schedule	OceanGate stops all operating activities	
	Equipment, Property	Loss of OceanGate Titan, naval resources deployed in search and rescue	
	Labor, Time	?	
		This incident	?
	Frequency	1x	
		Annualized cost	?

Timeline

Diagrams, Photos

Process Map

Timeline

Date	Time	Description	Source, Reference, Note
2009		OceanGate, LLC was founded by Stockton Rush, Guillermo Sohnlein, and Sarah Schwitters	
		Purchased ANTIPODES, 13-ft ABS classed A1 submersible (~305M depth) Applied for CG Certification, unable to attain due to sub-T regulations Attained oceanographic research vessel (ORV) designation and conducted dive operations (Puget Sound, Miami, San Francisco)	
2013		Purchased CYCLOPS I, 5-person 22 ft submersible with 500 meter capability Never applied for inspection from USCG; obtained oceanographic research vessel (ORV) designation from Coast Guard Sector Puget Sound in 2018 Entered contract with University of Washington- Applied Physics Lab for \$5 million for development, construction and testing of manned carbon fiber submersible, estimated time frame for vehicle (TITAN), 30 months	
2015		Conducted domestic operations using CYCLOPS I Began 1/3 scale model testing	
December 2015		1/3rd scale model failed during testing at 2,943 meters	
February 2016		1/3rd scale model failed during testing at 4,121 meters	
March 2016		1/3rd scale model failed during testing at 2,753 meters	
2016		ANDREA DOREA mission departed Boston, towed to dive site off Nantucket Island; charged "mission specialists" \$20K for a seat on submersible	
July 2016		1/3rd scale model failed during testing at 4,465 meters	
		The original plan was to utilize carbon fiber domes, but due to the failures in the 1/3rd scale models, they then switched to titanium domes and rings which were manufactured by TIFAB with no Coast Guard or Classification Society oversight	
2017		Carbon fiber hull was completed by Spencer Composites with no Coast Guard or classification society oversight; there was no non-destructive testing (NDT) conducted on the hull	
March 2017		OceanGate announces trips to the TITANIC; the price of an "SME" ticket is \$105,129 (\$4,350, the inflation-adjusted cost of a first-class ticket of the TITANIC on its maiden voyage)	
May 2017		OceanGate began conducting engineering work in-house on TITAN submersible	

Timeline

Date	Time	Description	Source, Reference, Note
July 2017		Carbon fiber hull and titanium rings were bonded together on TITAN by OceanGate employees using an adhesive	
December 2017		Final mechanical inspection report for conical frustrum dome window completed by Hydrospace Group	
2018		Obtained oceanographic research vessel (ORV) designation from Coast Guard Sector Puget Sound	
January 2018		The TITAN was fully assembled	
February 2018		First manned dive in TITAN submersible to 3 meters	
April 2018		TITAN arrived in Bahamas, allegedly struck by lightning, delaying scheduled test dives	
December 10, 2018		Stockton Rush performs solo descent in TITAN to 3,939 meters	
April 2019		Completed a dive in TITAN to 3,760M w/ 4 total crew	
June 2019		OceanGate pilot visually identified a large crack on the internal surface of the carbon fiber hull of the TITAN TITANIC Expedition 2019 cancelled citing complications to do with the status/flag of the support vessel MV HAVILA HARMONY	
October 2019		TITAN tested at Deep Ocean Test Facility; Hull showed signs of fatigue, hull derated to 3000M	
2020		Hudson Canyon Mission (2020) departed New York, towed by offshore supply vessel (OSV), "mission specialists" paid \$35K for dive OceanGate contracted local WA company, ElectroImpact, to build 2 1/3 scale models and the new carbon fiber hull utilizing the Automated Fiber Placement (AFP) system The full-size hull was cured after every ~ inch in an autoclave at Janicki Industries Titanium domes and rings were removed from prototype hull and used on final hull 16 strain gauges and 8 acoustic emission sensors were affixed to the inside of the hull to act as a Real Time Monitoring hull assessment The outside of the hull was covered with a polyurethane coating prohibiting any external visual inspection of the carbon fiber hull	

Timeline

Date	Time	Description	Source, Reference, Note
March 2021		<p>Completed TITAN hull was tested at Deep Ocean Test Facility in MD</p> <p>Day 1: max depth of ~4,000M (5,858psi for two cycles (30 min and 40 min))</p> <p>Day 2: max depth of ~4,200M (6,154 psi for one 20-minute cycle)</p> <p>Day 3: max depth of ~3,840M (5,627psi for one 240-minute cycle)</p> <p>Day 4: max depth of ~3,840M (5,628 psi for one 240-minute cycle)</p>	
June 2021		<p>Mobilized to St. Johns, Newfoundland, Nova Scotia, Canada and began 2021 Expedition</p>	
2021 Expedition		<p>Conducted 1 test dive (dive #63) to depth on TITANIC (3,840M) before carrying paying passengers/"mission specialists"</p> <p>70 equipment issues requiring correction including:</p> <ul style="list-style-type: none"> - Forward dome fell off during recovery - Multiple drop weight issues to include the tray being jettisoned due to malfunction - Drop weight and thruster failure at 3,500 meters - Platform damaged on recovery <p>Departed Canada via flatbed; conducted 4-month road show to market TITANIC Expeditions (locations included: South Kingstown, RI; Atlanta, GA; Lake Forest, IL; Los Angeles, CA)</p>	
6/28/21 - 8/6/21			
2022 Expedition		<p>13 dives attempted, 7 successful to TITANIC (3,840M)</p> <p>Conducted 1 test dive to 7M, with passengers, prior to diving to depth</p> <p>48 equipment issues documented during expedition - major incidents include: batteries died on TITAN, extending the time inside TITAN to 27 hours; platform damaged during recovery, TITAN aft fairing torn off, Data Voyage Logger INOP below 500M, TITAN damaged during recovery, drop weights malfunction, thrusters mapped in reverse</p> <p>Upon completion of 2022 Expedition, TITAN was stored at shoreside facility in parking lot along dock without protection from elements (uncovered) from July 26th, 2022 to February 6th, 2023</p>	
6/14/22 - 7/25/22			
2023 Expedition		<p>Due to high charter rates and non-availability of support vessels based on increase in offshore oil production, 2023 Expedition utilized the M/V POLAR PRINCE, a Canadian Flagged Research Vessel (old Canadian Coast Guard tug)</p> <p>Due to the lack of deck space, launching appliances, and weight handling equipment, the LARS/ TITAN were to be towed behind the POLAR PRINCE for the entirety of each mission</p> <p>Missions 1 thru 4, which began on May 12th, transited a total ~3,600 nautical miles with TITAN in tow; completed 4 dives, none of which left platform (10M)</p>	

Timeline

Date	Time	Description	Source, Reference, Note
Mission 1		POLAR PRINCE departed on May 11th to Conception Bay to rendezvous with the TITAN (which was at the Marine Institute Holyrood Launch) to conduct "familiarization" training	
5/11/23 - 5/19/23		No Mission Specialists were aboard; no dives completed	
Mission 2			
May 20, 2023		POLAR PRINCE departed St. Johns on May 20th enroute TITANIC with TITAN in tow at an average speed of 7.4 knots (8.4 mph)	
May 22, 2023		Conducted unmanned dive to 8 meters (Dive 84)	
May 24, 2023		After a night of high seas and fog, the TITAN and its platform were found partially sunk in the morning with the tail cone fairing ripped off	
May 27, 2023		Conducted post incident test dive, recorded 13 equipment issues requiring correction	
Mission 3			
May 29, 2023		POLAR PRINCE departed St. Johns and proceeded to Witless Bay to continue checks from the May 24th incident	
May 30, 2023		Completed post check dives	
May 31, 2023		Dive 85 completed to 10M	
June 5, 2023		Dive 86 completed with 3 mission specialists	
Mission 4			
June 7, 2023		Departed St. Johns; due to weather at the TITANIC site, the POLAR PRINCE transited 400 nautical miles to the northwest of the TITANIC site	
June 12, 2023		Dive 87 completed, ended early due to a variable ballast tank issue Upon resurfacing, error caused platform to become inverted to ~45 degrees, slamming all 5 occupants to the aft of the submersible TITAN became partially disconnected to the LARS and slammed the submersible and the occupants for ~1 hour until the platform was corrected	
Mission 5			
June 16, 2023	9:31 AM	POLAR PRINCE departed St. Johns with 42 total persons on board Tow of TITAN set to 250 meters astern of the vessel	
June 17, 2023		All hands meeting, training, lunch, presentation, and dive plan review in evening	
June 18, 2024	5:15 AM	POLAR PRINCE arrived in vicinity of the TITANIC wreck site location	

Timeline

Date	Time	Description	Source, Reference, Note
		Shortened tow, traveled at ~8.3 knots	
	5:30 AM	15 min final dive brief was held in the helicopter hanger Final risk for Dive 88 was calculated at 35	
	5:48 AM	The accommodation ladder had been placed over the side of the vessel (an accommodation ladder is a set of stairs used for transitioning from a vessel to another vessel or dock)	
	5:58 AM	A 16' Seamax rigid hull inflatable boat (RHIB), was launched, which was crewed by the Dinghy Captain, Diver #1, Diver #2, and Dive Support	
	6:24 AM	Another RHIB was launched and transited to the platform (this was the same type of vessel as the other and was crewed by the Dingy Captain, Platform Operator, and Platform Assistant)	
	~6:30 AM	The divers commenced their dive and TITAN vessel checks commenced.	
	~7:35 AM	One of the rigid hull inflatable boats was loaded with the Dive 88 crew to transport them to the LARS platform	
	~8:30 AM	The five members of Dive 88 were loaded into the TITAN and the forward dome was secured	
	~8:55 AM	The platform was vented, causing it to sink to the operational depth of 30 feet below the surface of the water	
	9:14 AM	The TITAN disengaged from the platform, maneuvered away, and proceeded to dive with five persons on board	
	9:18 AM	POLAR PRINCE sent a "k" communication to the TITAN (according to the OceanGate Communications Sheet, "k" means comms check); the approximated depth of the TITAN was 165 meters (M); 44 seconds later, the TITAN requested a comms check with a communication of "k" to the POLAR PRINCE; the POLAR PRINCE received a "ping" from the TITAN approximately every 5-10 seconds	
	10:47 AM	The TITAN messaged, "dropped two wts"; the depth of the TITAN was approximately 3341 M; this was the last message that was sent from the TITAN	
	10:47 AM	TITAN was pinged for the final time; the TITAN's location was 41.73441N; -49.9424E. The depth of the TITAN was 3346 M	

Timeline

Date	Time	Description	Source, Reference, Note
	10:49 AM	POLAR PRINCE sent a message to the TITAN that stated, "lost tracking;" there was no response; the POLAR PRINCE continued messaging the TITAN two to three times per minute, with no response	
	11:15 AM	Master of the POLAR PRINCE was advised that as of approximately 10:47 a.m., there was a loss of communication with the TITAN	
June 22, 2023	10:50 AM	The Pelagic Research Services 6000 remotely operated vehicle (ROV), which had been searching since arrival at the distress location, discovered the aft tail cone and other debris of the TITAN on the seafloor after extensive searching	

Photos



TITAN submersible with Launch and Recovery System in tow behind the Polar Prince



TITAN mounted on Launch and Recovery System



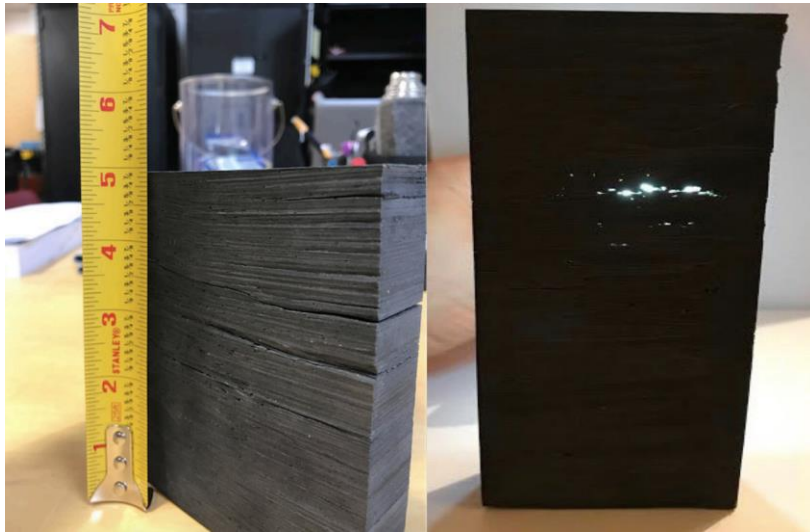
Polar Prince in 2023 ahead of the 2023 Expedition



Picture of typical storage for TITAN submersible in winter



Photos



Cut off of carbon fiber pressure vessel, indicating multiple delaminations, voids in carbon fiber



Rear fairing, as found on seafloor at 3776M deep near titanic wreckage

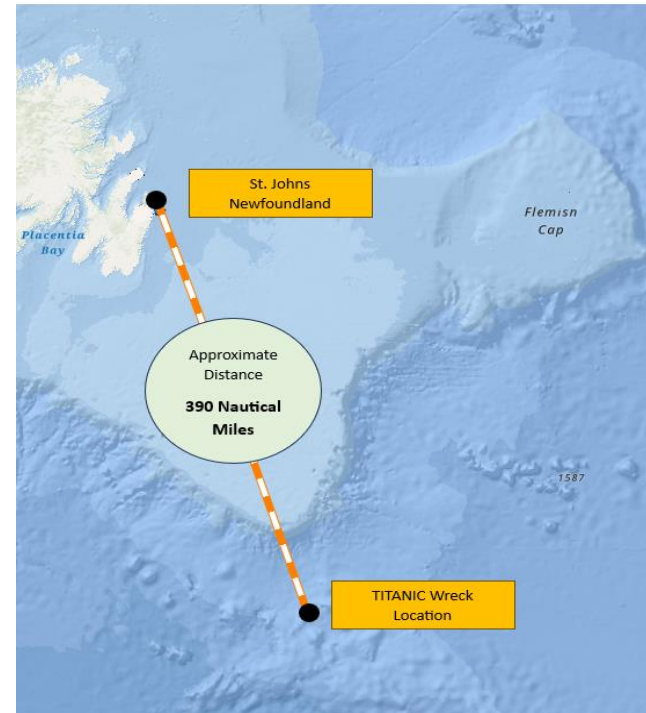
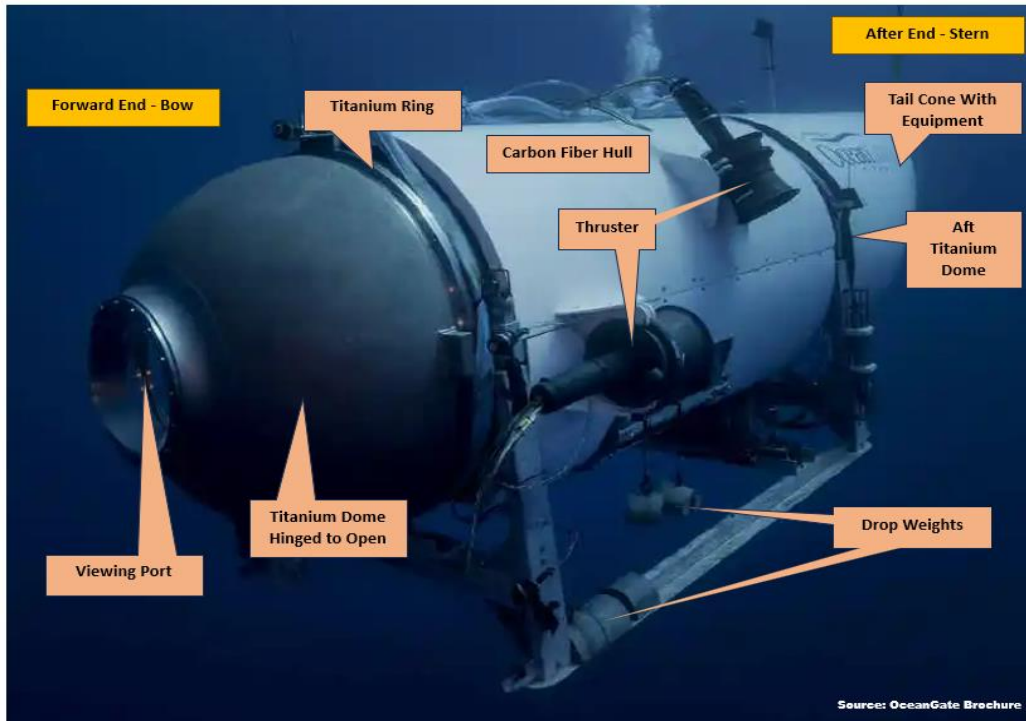


Rear Titanium hemisphere and carbon fiber pressure vessel as found on ocean floor



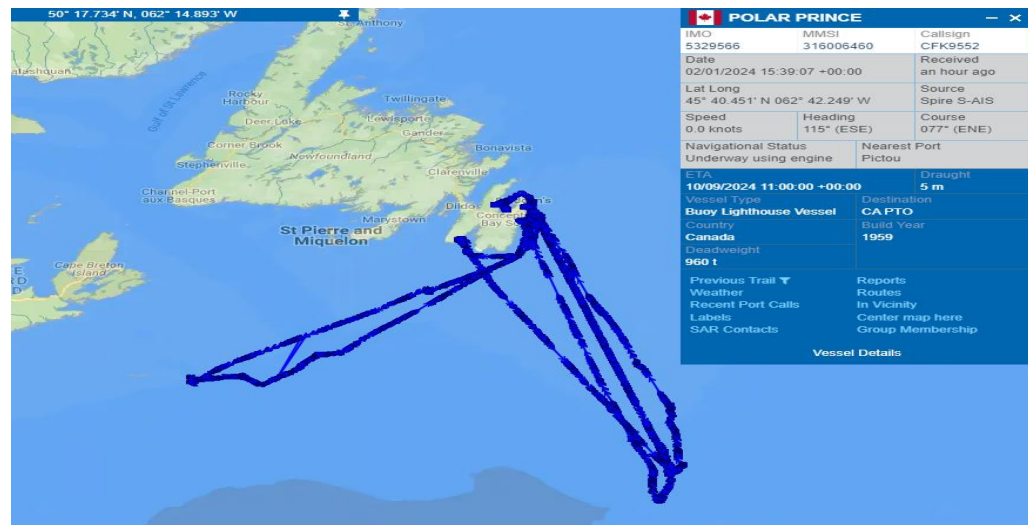
Front titanium hemisphere, as found on ocean floor

Diagrams - Titan and Titanic Expedition 2023



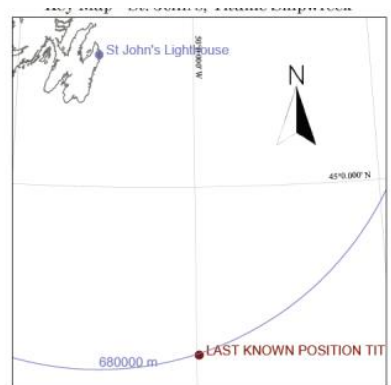
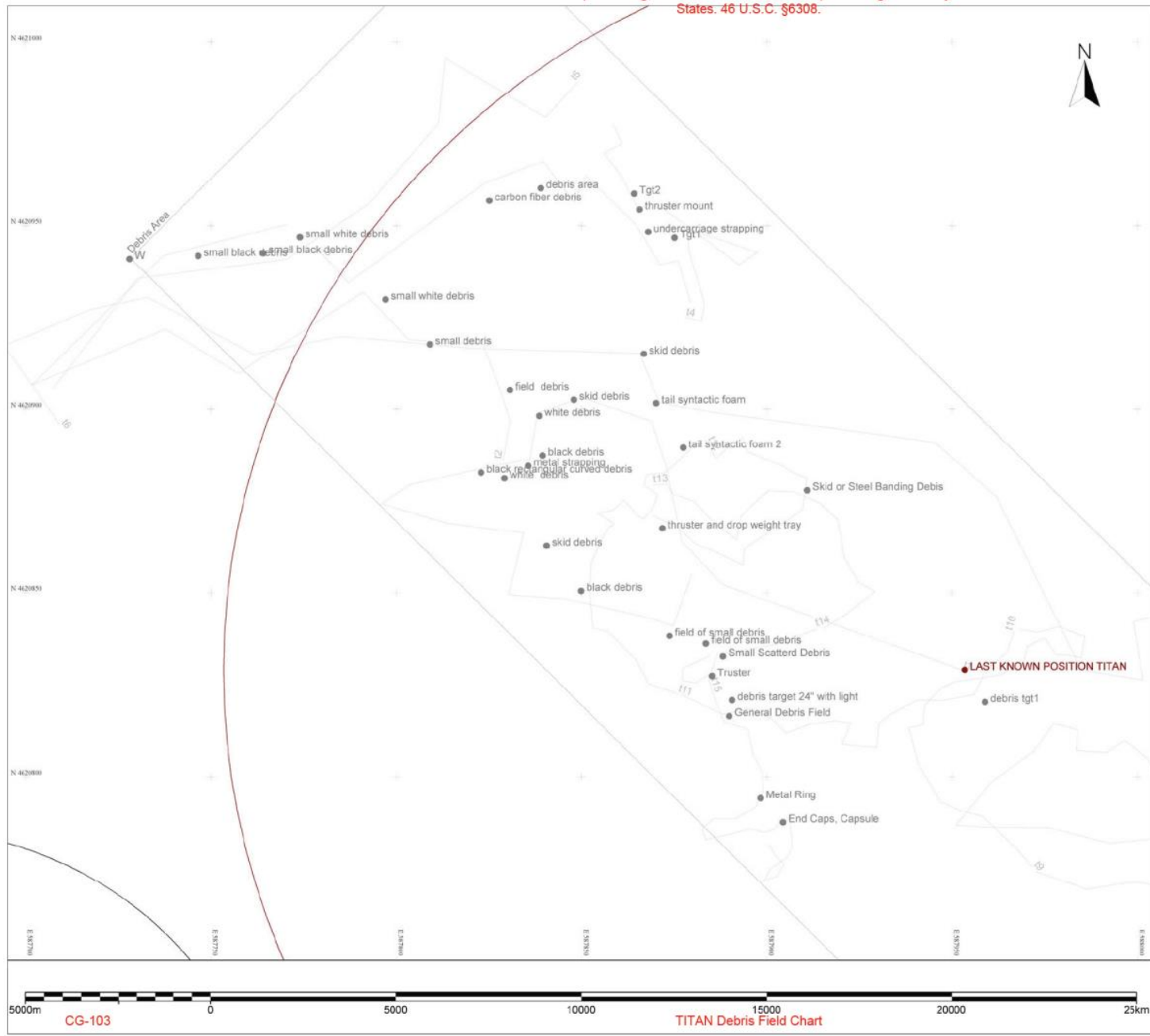
Typical journey from St. Johns Newfoundland to TITANIC Wreck location

Official Name:	TITAN
Identification Number:	None
Owner/Operator:	OceanGate, Inc. Everett, WA USA
Vessel Class/Type/Sub-Type:	Submersible
Build Year:	2020
Gross Tonnage:	23,000 pounds
Length:	22 feet
Beam/Width:	9.2 feet
Vertical Height:	8.3 feet high
Main/Primary Propulsion:	4 Innerspace 1002 electric thrusters



Track of the Polar Prince during the 2023 Expedition

Diagrams - Debris Field



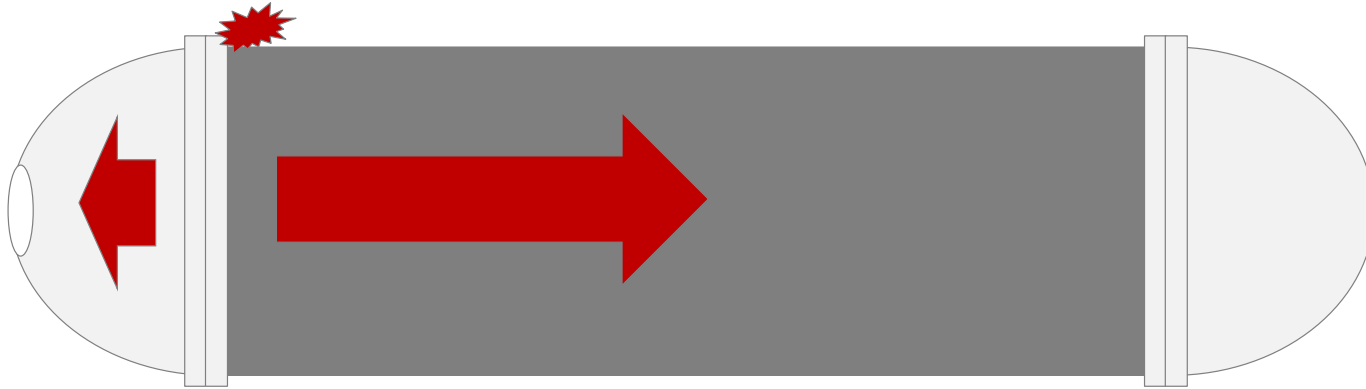
Description	Easting	Northing
	utm 22N	utm 22N
	meters	meters
Titanic Bow	587668	4620686
Last Known Position TITAN	587953	4620829
South	487962	4620706
West	587728	4620941
North	587821	4621034
East	588055	4620799



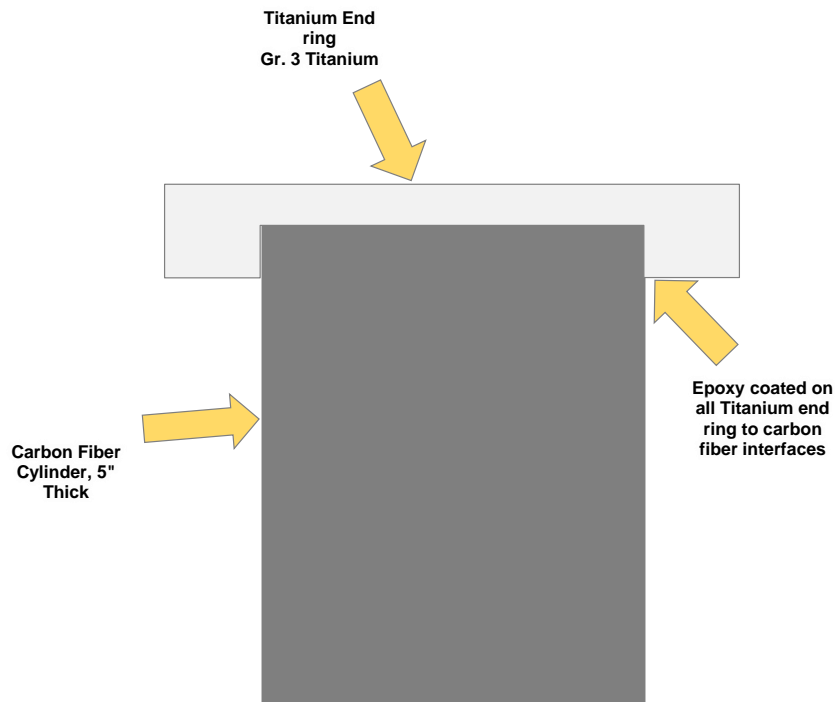
Datum	NAD83
Spheroid	GRS80
Units	meters
Projection	Universal Transverse Mercator (North)
Zone	22
Project	Search Rescue Recovery TITAN
Title	Debris Field-Dive001
Location	North Atlantic Ocean, near Titanic Shipwreck
Dates	June 18 - 29, 2023
Vessel	Horizon Arctic
Prepared by	[Redacted]
Sheet #	Map 3 of 3
file name	Plot003-Map3-Debris Field Dive 001
revision	000



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Approximate theory of forces associated with end ring failure



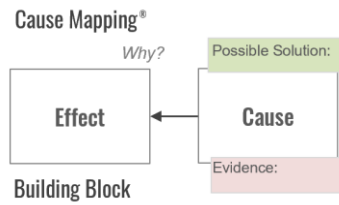
Approximate joint interaction of carbon fiber to end ring

Diagrams - Dive History

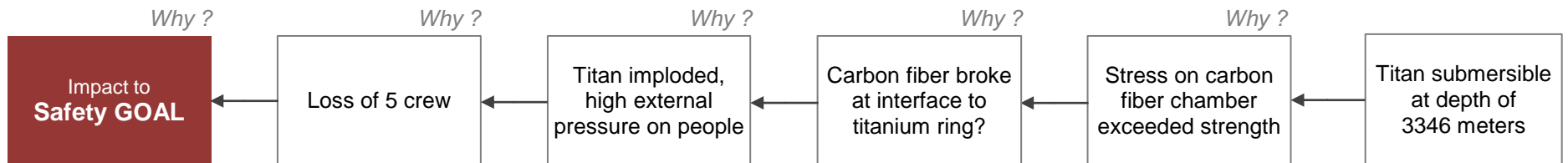


OceanGate Titan Implosion - 5 fatalities

Analysis

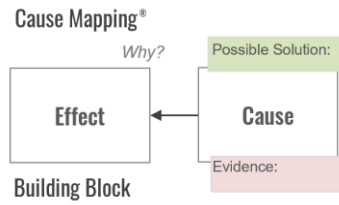


Cause Map™ Diagram

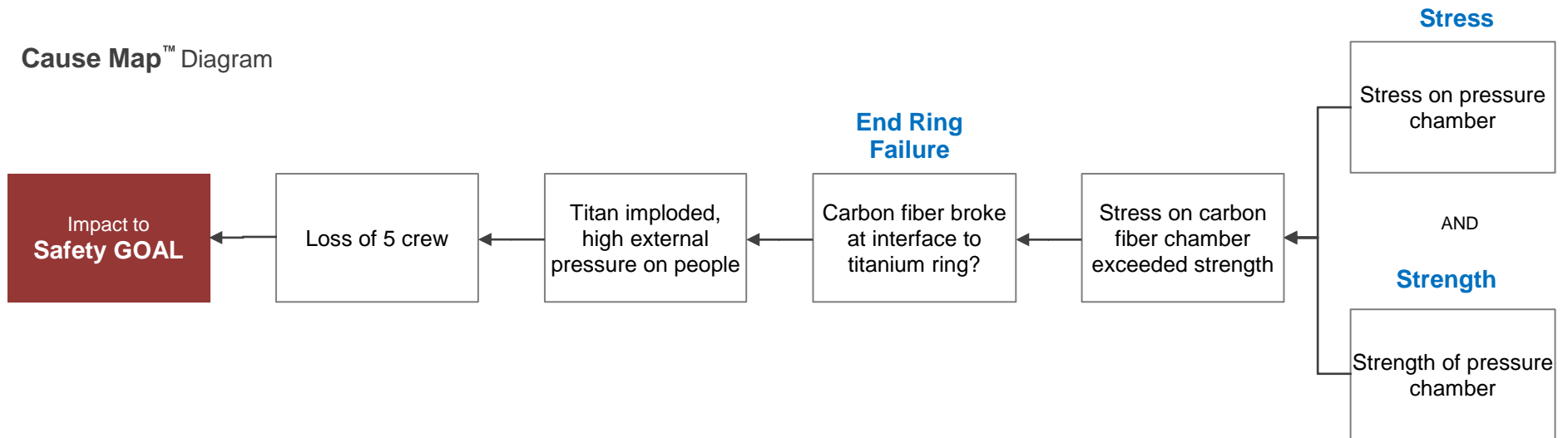


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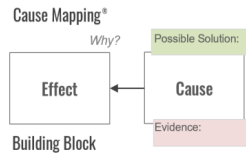


Cause Map™ Diagram

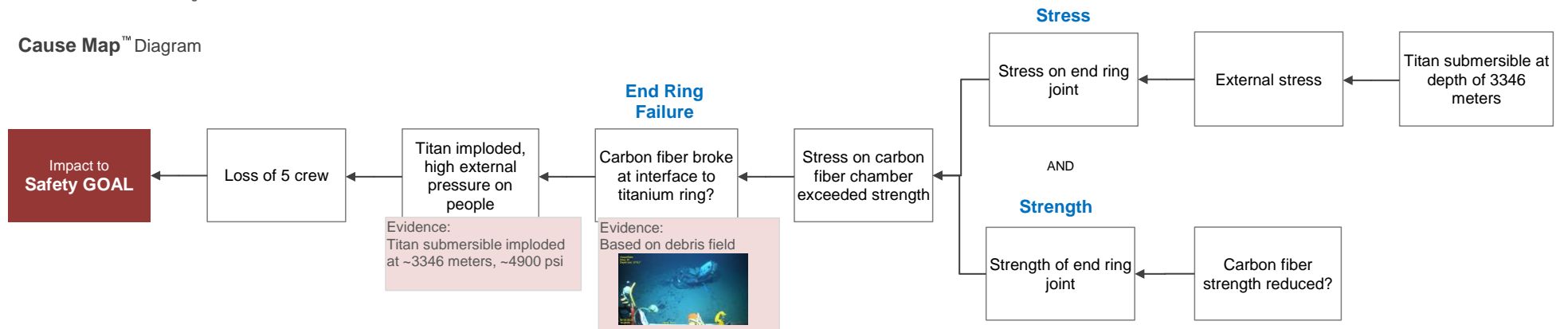


OceanGate Titan Implosion - 5 fatalities

Analysis



Cause Map™ Diagram

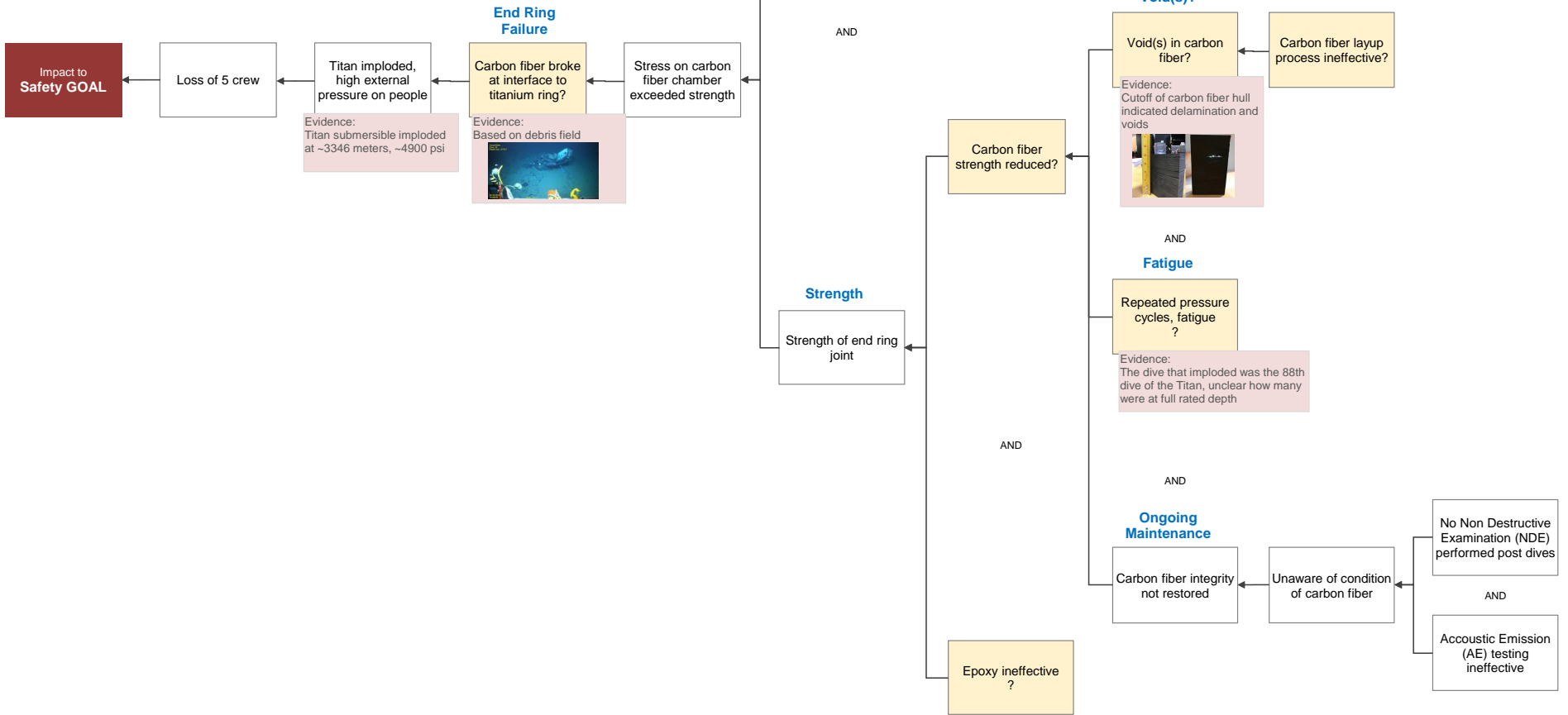


OceanGate Titan Implosion - 5 fatalities

Analysis



Cause Map™ Diagram

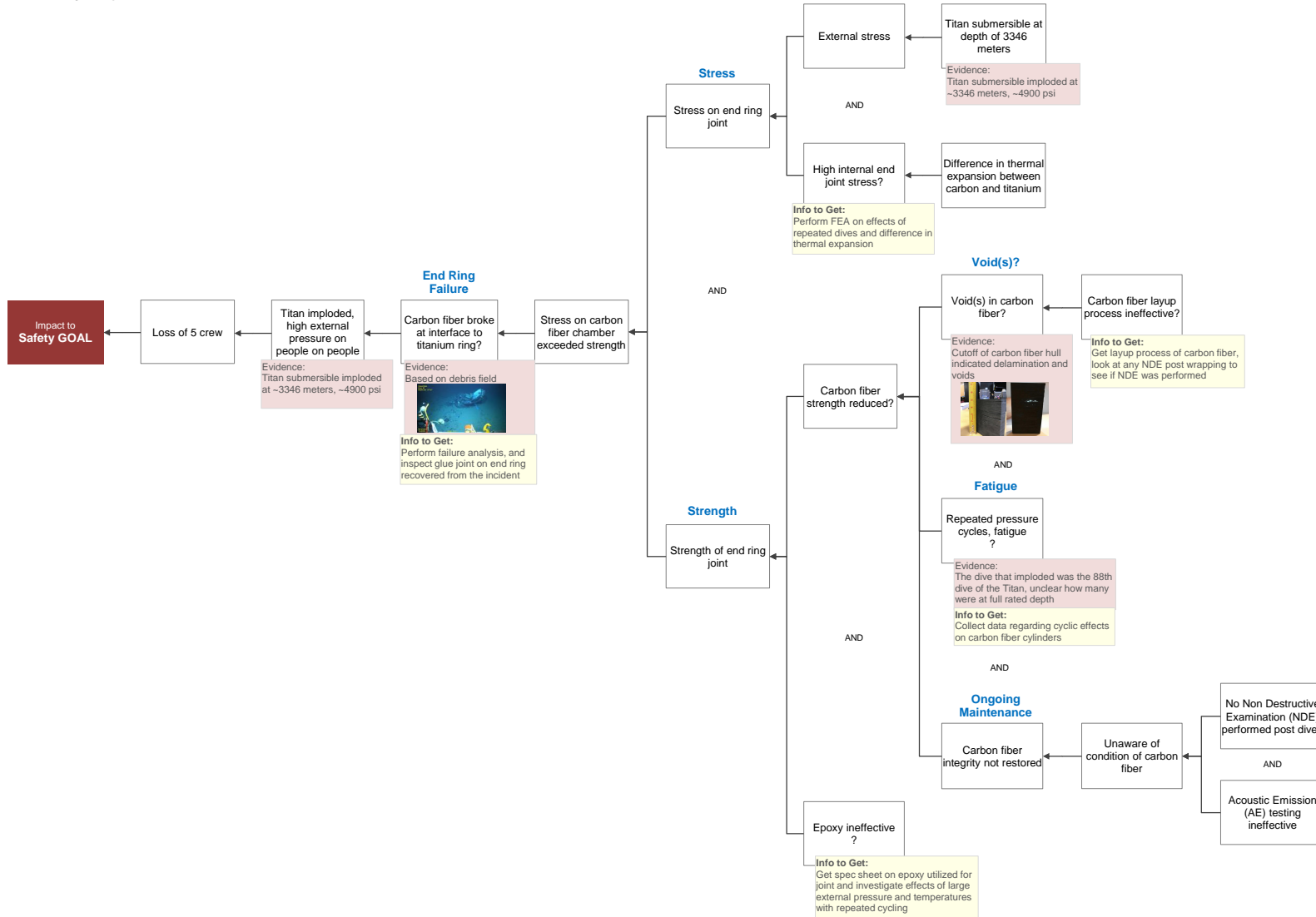


OceanGate Titan Implosion - 5 fatalities

Analysis



Cause Map™ Diagram



Information to Get

No.	Information and Evidence to Collect	Owner	Date Created
1	Perform failure analysis, and inspect glue joint on end ring recovered from the incident	US Coast Guard NTSB	September 24, 2024
2	Perform FEA on effects of repeated dives and difference in thermal expansion	US Coast Guard NTSB	September 24, 2024
3	Get layup process of carbonfiber, look at any NDE post wrapping to see if NDE was performed	US Coast Guard NTSB	September 24, 2024
4	Collect data regarding cyclic effects on carbon fiber cylinders	US Coast Guard NTSB	September 24, 2024
5	Get spec sheet on epoxy utilized for joint and investigate effects of large external pressure and temperatures with repeated cycling	US Coast Guard NTSB	September 24, 2024

Solutions - Action Items, Recommendations

<i>Ref.</i>	<i>Recommendation, action, control, idea</i>	<i>Cause to be controlled</i>	<i>Task to be improved</i>	<i>Why or why not it was selected</i>	<i>Solution details if needed</i>	<i>Owner(s)</i>	<i>Due Date</i>	<i>Status</i>	<i>Evidence it was effective</i>	
Ref.	Possible Solution	Cause	Work Process	Rationale	Specific Action	Owner(s)	Due Date	Status	Measurement	
1										
2			Solutions to be developed / populated after the US Coast Guard, and NTSB complete their investigation							
3										

Solutions Matrix

Evaluate the Different Possible Solutions

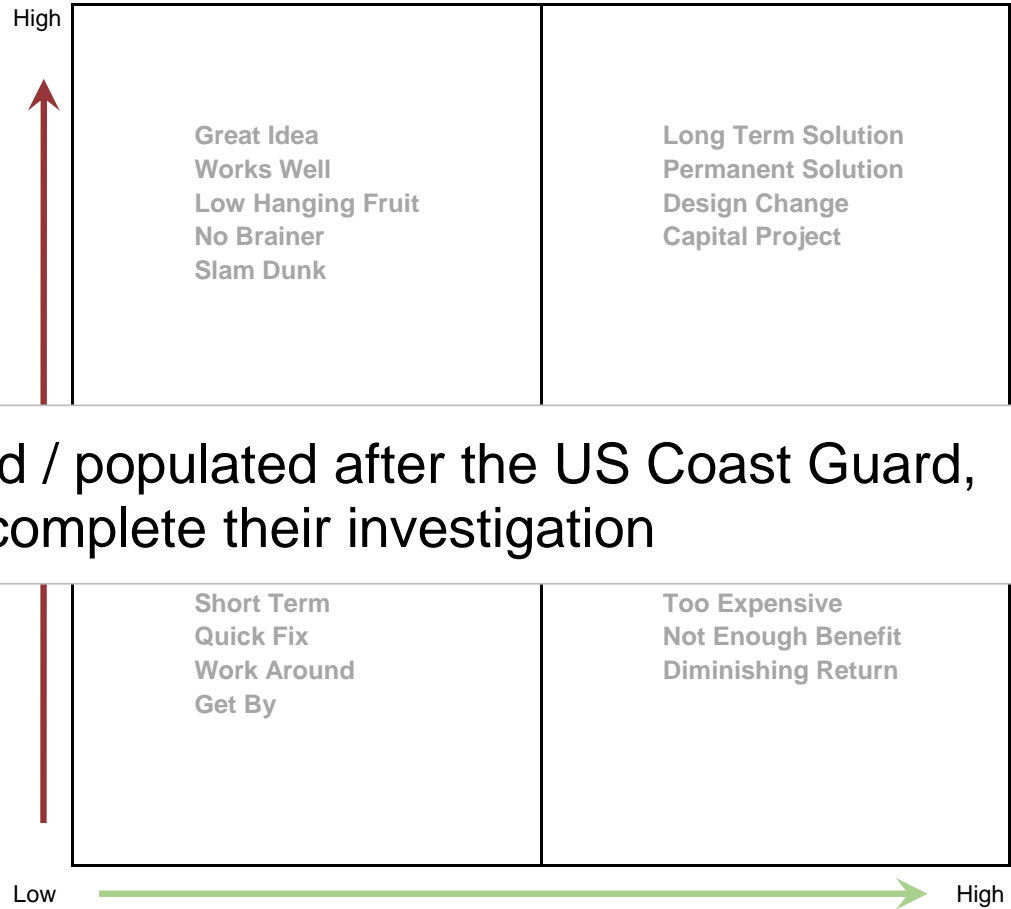
Possible Solution:
Idea, suggestion.

A B C D

Estimated

1 2 3 4

5 6 7 8



Estimated **COST** of Solution
Expected **Effort** In

- Scope-Function-Quality
- Time-Schedule
- Cost-Budget
- Resources

Resources

Title	Source	Format	Note	Link
How many expeditions did OceanGate submersible make to see Titanic? When were they?	AS USA	Website		https://en.as.com/latest_news/how-many-expeditions-has-the-oceangate-submarine-made-to-the-titanic-when-were-they-n/
Imagery Library	USCG Titan Submersible Marine Board of Investigation Document Library	Website		https://www.news.uscg.mil/News-by-Region/Headquarters/Titan-Submersible/
Titan Submersible Hearings	USCG YouTube	Website		https://www.youtube.com/playlist?list=PLqOie37c-b1NswzbM8kMEGRrdup_xwIW9
Wreckage of Titan Submersible Reveal How It Imploded	Scott Manley YouTube	Website		https://www.youtube.com/watch?v=CxBtZmyPzVA