CHAOS

THEY'VE GOT METHANE ON US

PAYLOAD CONCEPT PROPOSAL

Chaos

Team 3

Da Vinci School for Science and the Arts

1.0 Introduction

Chaos has come together with one specific goal in mind, to be able to succeed in designing an efficient and durable payload, ours deemed "The Dart", that would be able to not only fulfill a definitive science objective, but also to provide NASA with worthy information and measurements that will benefit the scientific community. Our team is filled with eight dedicated members that have given their complete input in crafting a clever payload design that is worthy of being chosen by NASA to complete our science objective. Our team name, Chaos, relates to our objective in that we will discover the origin of a very crucial element present within the moon Titan's atmosphere and who better to discover the origin of something than the creator of all that is, the Greek Titan: Chaos. Our slogan is "They've got methane on us", referring to that crucial element.

2.0 Science Objective and Instrumentation

Our science objective has been split into two distinguishable parts, both yielding significant results.

The first part of this science objective is to determine if, in fact, the mountainous region on Titan's surface known as Sotra Facula possess cryovolcanic qualities. A cryovolcano is much like a volcano found on Earth, except instead of spewing lava as one would normally, a cryovolcano erupts ice, or in Titan's case, liquid methane. NASA's previous missions to Titan, specifically the Cassini-Huygens mission in 2004, had generated the possibility of cryovolcanic activity occurring in the Sotra Facula area. This was backed up with infrared imaging suggesting the possibility of frigid ice and frozen methane near the area. We will conduct our science objective by ejecting our payload from NASA's orbiter 1000 kilometers from Titan's surface, at which point we will fall toward the specific coordinates of 15° south, 40° west, longitude. At around 10 kilometers form the surface, we will eject a parachute from the payload to slow down its descent and land delicately around Sotra Facula. Once landed, our payload will activate an instrument known as the Titan Radar Sounder, which will send radio waves through the surface and subsurface of Titan in search of underground methane deposits, much like how underground wells of water are found here on Earth. This will prove whether or not methane pools exist underneath Sotra Facula.

Our second part to this science objective is determining the concentration of methane in and around the cryovolcano. This is to be executed in two distinct ways, the first of which was described above in detecting large or multiple underground deposits of liquid methane beneath Titan's surface. The second way to determine this measurement would be conducted during our descent into Titan's atmosphere. Once the Sotra Facula area has entered the range of our payload from above, we will have an infrared spectrometer ready to detect methane traces. This will be done using similar infrared imaging technology like that used by the Cassini probe from NASA's previous mission. We hope to discover large concentrations of methane emanating from the volcano's entrance to prove that eruptions from Sotra Facula do indeed spew liquid methane.

At this point, one might be asking, "Why is methane so important?" The answer to that question can, or rather could have been found right here on Earth. Before the Earth was the life sustaining, oxygen composed planet we all benefit from today, its atmosphere was highly composed of methane. This relates to the moon Titan, in that it may also have the unique ability of being able to sustain life. The methane found on these interstellar bodies may be the building blocks that add on the support of life. Our science objective possesses the ability of relating Titan to the creation of the most important planet in our solar system, the Earth.

Table 1. Science Traceability Matrix

Science Objective	Measurement Objective	Measurement Requirement	Instrument Selected
To determine if Sotra Facula is a cryovolcano.	Analyzing radio waves through the surface and subsurface interfaces between layers of different material to determine cryovolcanic origin.	The Titan Radar Sounder landing within the proximity of Sotra Facula.	-Argus 1000 Infrared Spectrometer -Titan Radar Sounder
If confirmed to be a cryovolcano, we will measure if methane originates from it and the rate at which it is created.	Analyze energy and mass fluctuations to determine properties of methane.	Analysis of Sotra Facula during descent and landing of payload.	

Table 2. Instrument Requirements

Instrument	Type	Mass (kg)	Power (W)	Data Rate (Mbps)	Lifetime	Frequency	Duration
Titan Radar Sounder	P	2.18	27	0.280	Until Payload ceases to send data or function properly.	Continuous	Continuous
Argus 1000 Infrared Spectrometer	P	0.230	1.5	2.4		Continuous	Continuous

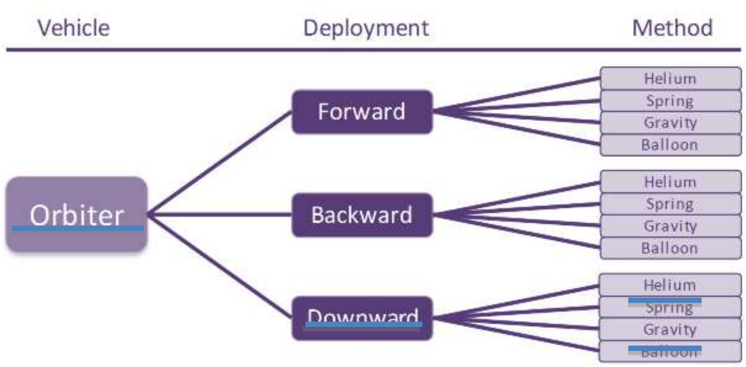
3.0 Payload Design Requirements

In order for our science objective to be successfully completed, our payload first has to meet a series of requirements. These constraints are placed upon us through Titan's harsh environment and given by the InSPIRESS project. First of all, our payload has to weigh in at 10kg or less, due to NASA being unable to hold something of a heavier weight. Also specified by NASA are the dimensions of the payload, which cannot exceed 44cm x 24cm x 28cm. Due to the harsh conditions of Titan, our payload is also required to be able to survive the frigid temperature of -290°F, high winds that may be able to throw it off course and a pressure 1.6 times that of

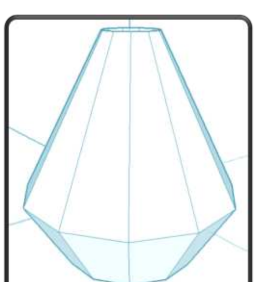
Earth's. As required by NASA, we may NOT, in any way, harm or disturb the main spacecraft that is housing our payload. The final requirement our payload must be able to meet is the ability to conduct its measurements autonomously.

4.0 Design Choices

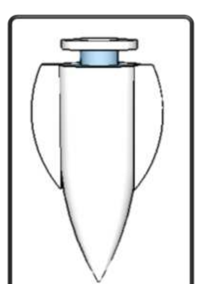
There are several design choices made available to our team concerning the deployment of our payload. These choices allowed us to carefully evaluate multiple options until we were comfortable with the most efficient method that we believed would best suit our science objective. In terms of getting to Titan, our team was offered three forms of transportation before we begin conducting our measurements. These three methods included being carried upon the orbiter, on a balloon or on a lake lander. Chaos selected to deploy from above Titan's atmosphere allowing us to pinpoint the exact coordinates of Sotra Facula from above and conduct measurements during our decent. After choosing the orbiter, we were next faced with deciding the direction to eject our payload. Our choices included forward, backward and downward. Since our payload is falling, we decided the best direction to jettison in was downward, straight toward the cryovolcano. From here we had to choose the method we would be using to deploy our payload from the orbiter, having to choose from helium, spring, gravity or a balloon. Considering we are in orbit, both gravity and the balloon would not be possible at the time, we decided upon using the helium pressure to push us out of the orbiter's muzzle. After entering Titan's atmosphere we will allow gravity to take over and pull us toward the surface.



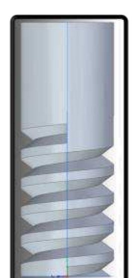
In terms of alternative payload designs, our team had gotten together and came up with three distinct versions. Each one followed the same deployment method, the differences only lying in the design and shape of the payloads. We came up with these designs by splitting our team into two separate groups, one led by the Project Manager and the other led by the Chief Engineer. The concepts we came up with are as follows:



Concept 1: Diamond Drop



Concept 2: Torpedo



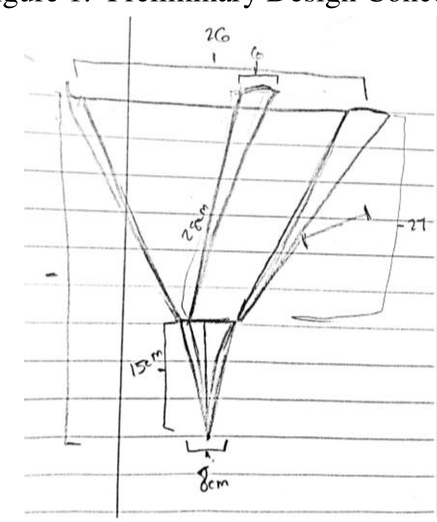
Concept 3: Feather Arrow

FOMs	Weight	Torpedo		Diamond Drop		The Dart	
	1, 3, or 9	RS	WS	RS	WS	RS	WS
Science Objective	9	9	81	9	81	9	81
Likelihood Project Requirement	9	9	81	9	81	9	81
Science Mass Ratio	3	9	27	9	27	9	27
Design Complexity	1	3	3	9	9	1	1
ConOps Complexity	1	1	1	1	1	1	1
Likelihood Mission Success	9	9	81	3	27	9	81
Manufacturability	3	6	18	9	27	6	18
Survival of Environment	9	3	27	3	27	9	81
Control	3	9	27	1	3	9	27
Data Quantity	9	9	81	9	81	9	81
TOTAL			**427**		**364**		**479**

5.0 Preliminary Design

After evaluating all three payload concepts carefully through our included Decision Matrix, we eventually decided to combine elements from each of the payloads to come up with an entirely different design for Concept 3. The design was retooled and rebranded as “The Dart”. With this new concept we hope we will be able to generate accurate measurements and survive Titan’s harsh environment. We first developed a quick sketch of this payload before finalizing the design in SketchUp.

Figure 1. Preliminary Design Concept



6.0 Design Analysis

After deciding upon our final design, we proceeded with figuring out the specifications for the instruments within the payload and the physics our payload will be enduring as it ejects from the orbiter and enters Titan's atmosphere. We first distributed mass specifications to the payload, accounting for the mass of all our instruments, the aerogel insulation and the carbon-nano tubing that will house our payload. To begin with the mathematical/physical aspects of our payload, we began with calculating the velocity the orbiter would be traveling around the payload. After this, we knew our payload would have to be ejected at a speed of at least 1% of the speed the orbiter is traveling at. We went with this measurement and proceeded to calculate the speed at which our payload would be traveling once it entered the atmosphere of Titan. Our payload would be guaranteed to be traveling extremely fast, due to Titan's gravitational pull once we entered the atmosphere. We would travel at this speed, accounting only for a minor drag force, for 990 kilometers from Titan's surface. Once 10 kilometers from the surface our payload would experience a major drag force due to the winds that would drastically change the speed at which we are falling. Around entering this 10 kilometer measurement, our payload will deploy a parachute 3 feet in diameter to slow the descent even more. This will allow for our payload to land softly around the Sotra Facula region and begin conducting measurements.

7.0 Final Design

Our final payload design was given the name "The Dart", mostly due to its design and shape. The payload is shaped like a hexagonal pyramid, with a sharper tip extending at the payload's end. Aside from the literal naming of our payload, we also named it as such because a dart is meant to always hit its mark, which is what we aim to achieve with the completion of our science objective. The Dart was designed to not only be aerodynamic, but also sturdy and durable, due in part to the science objective it is set out to complete. This payload will have the best chance at completing our science objective thoroughly and efficiently. This design also meets all of the design requirements by abiding to the correct measurements to fit within NASA's orbiter, as well as weighing in at 9.2 kilograms, just below the 10 kilogram requirement.

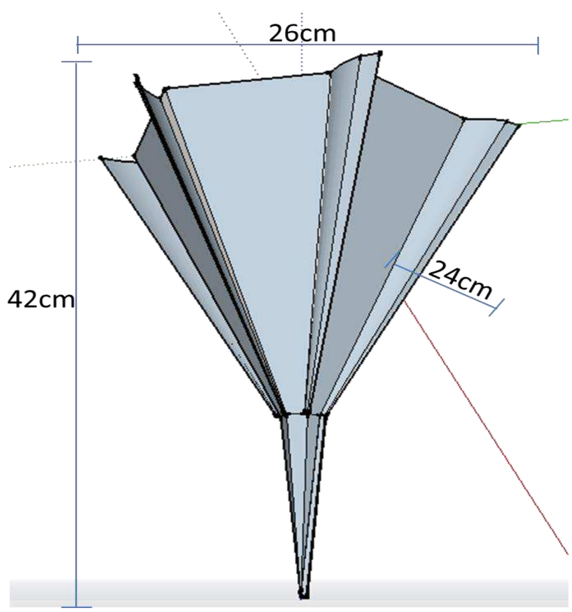


Figure 2. Chaos's Mission

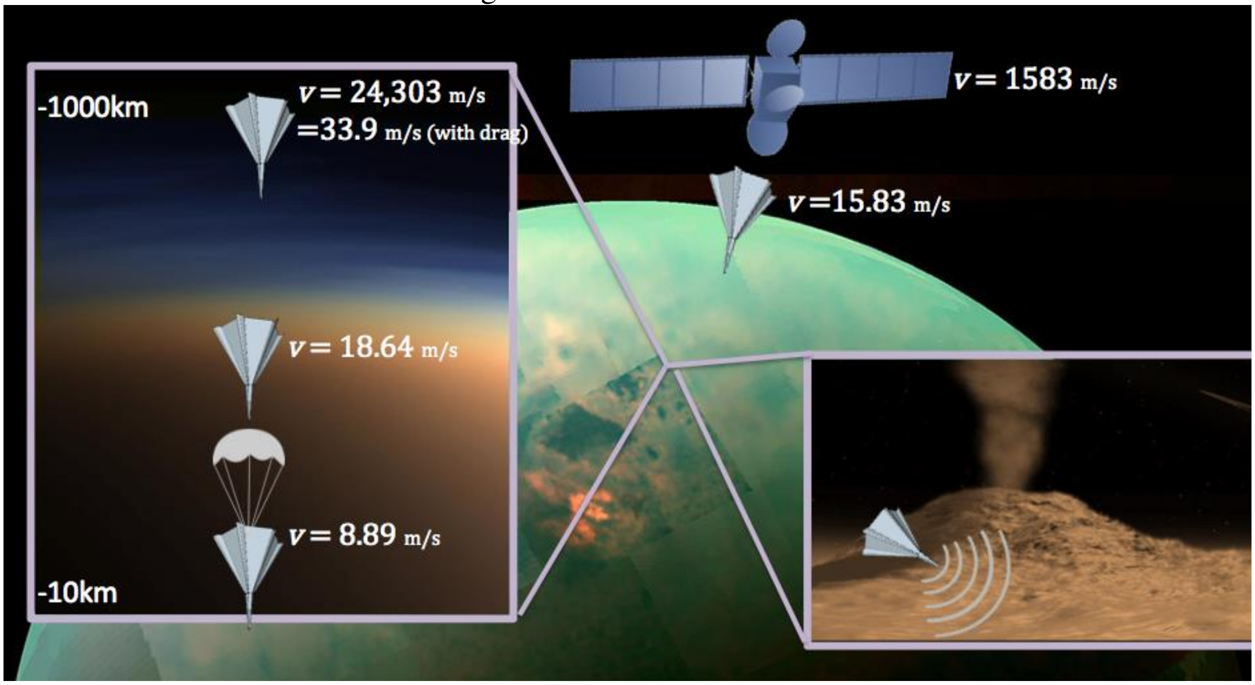


Table 3. Final Design Mass Table

Function	Component	Mass (kg)
Deploy	N/A	N/A
Measure	-Argus 1000 Infrared Spectrometer -Titan Radar Sounder	2.41
Collect Data	On-Board Computer	0.094
Provide Power	Space Batteries	1.75
Send Data	-Transceiver -Antenna	0.185
House/Contain Payload	-Carbon Nano Tubing -Aerogel Insulation	4.77
TOTAL		9.209