To extract the centerline and volume from the inflatable scan, I first used a method based on processing individual Regions of Interest (ROIs). This approach was chosen to handle the object's potential curves and complex geometry by dividing its volume into smaller, overlapping chunks. The core of this method was voxelization, where the points within each ROI would be converted into a 3D grid of voxels. However, I found that this method was not feasible for my large scan. The number of voxels required to maintain a clear resolution grew exponentially with the size of the ROI, quickly exceeding the memory capacity of my computer's RAM. Despite attempts to debug the code by processing tiny individual ROIs, the method proved impractical due to the parameters and expected results of the point cloud data. Therefore I decided to reproach the task with a more feasible method.

Given that the point cloud data represents a roughly elongated object, I decided to use a geometric centerline extraction method.
Reading and PCA: The process begins by reading the point cloud file and extracting the XYZ coordinates. I then performed a Principal Component Analysis (PCA) on these coordinates. PCA identifies the main axes of the data. For this object, the main axis of variation was the longitudinal axis (z-axis), which PCA identifies as the primary axis. A coefficient matrix containing the direction vectors for these axes was generated, with the first column corresponding to the primary axis.
Slicing the Object: All of the points in the scan were then projected onto this primary axis. Conceptually, this flattens the 3D data into a single line, allowing me to easily determine the object's length and define slicing planes. I defined 50 slices to be taken along the length of the object. The slice locations were set as 50 evenly spaced points between the start and end of the projected data. A slice thickness was then calculated to be 1.5 times the distance between slices, ensuring a necessary overlap to prevent gaps.
Centroid Calculation: The process then iterates through each of the 50 slices. For each slice, I found all points that fell within its boundaries. The average XYZ position of these points, known as the centroid, was then calculated. This centroid represents the geometric center of that slice and is a point on the object's centerline.
Plotting: After finding the centroid for each slice, all 50 points were stored in a matrix. A line was then drawn to connect these centroids, creating the final centerline. The *plot3* function was used to overlay this centerline on a 3D plot of the original point cloud, visually confirming the result.

To calculate the volume of the scan, I utilized the alpha shape function with the original point cloud locations. Alpha shape is a geometric tool that essentially creates a closed surface to accurately represent the object's volume. This method was preferred because it can accurately model any non-convex geometries found in the scanned objects, preventing any potential overestimation of the volume. Furthermore, the alpha shape function prevents minor scanning noise or small data gaps. The volume function then calculates the total enclosed volume of the alpha shape by summing the volumes of the tetrahedra solids that compose the alpha shape.The raw volume value is then converted from cubic millimeters to cubic inches through dividing by a conversion factor of 16387.064 mm^3 as that was the initial standard of measure to compare volume accuracy.