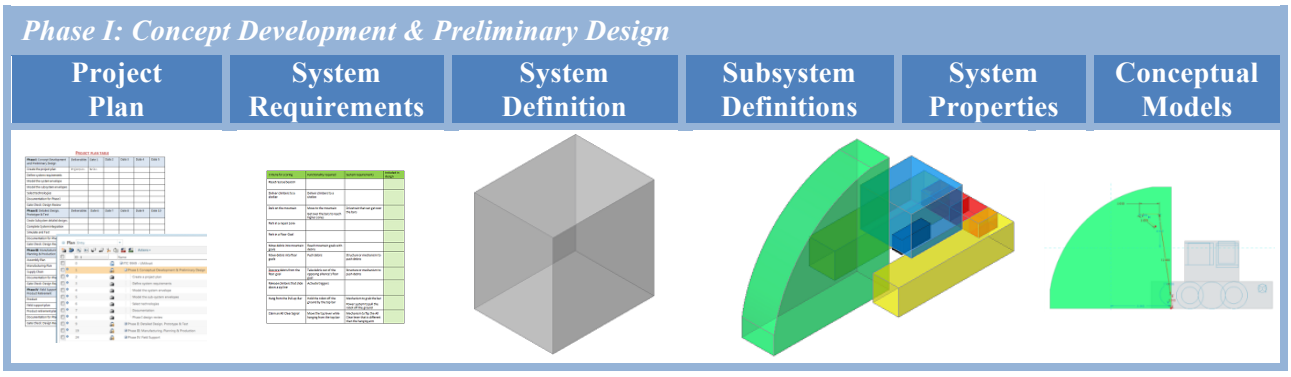
Let's break down the complexity of designing and building a robot through a product development process that allows you to engineer solutions to simpler tasks which, when taken together, form an integrated solution. That process has four phases that each contain a collection of deliverables and a gate check – giving you the chance to review and refine.

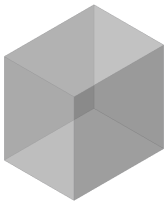
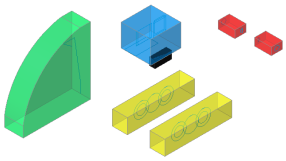
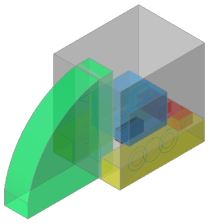
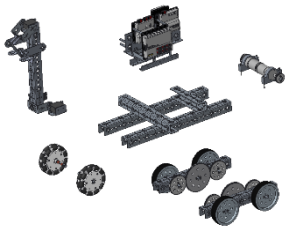
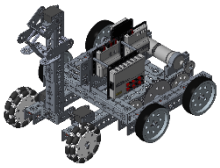
1. Concept development and preliminary design.
2. Detailed design, prototype, and test.
3. Manufacturing planning and production.
4. Field support and product retirement.



Defining the system envelope using Creo

A top-down design strategy organizes the various challenges involved in building a successful robot into levels that each contain a specific set of parts and important geometric or performance information.

Creo helps you model each phase of your design process.

Define the overall system size	Identify needed subsystems and their sizes	Position subsystems in a system assembly	Create detailed designs of subsystems	Integrate subsystems into a detailed system model
				

Your 3D models will consist of assembly models for the top-level system and each subsystem. The assembly models contain part models. In this activity you create an envelope model that subsystems can assembled within. The envelope model can be thought of as an invisible box your robot fits inside.

The system envelope model represents the top-level assembly. From within the system envelope, we create a skeleton model that defines the dimensions.

The skeleton model will be referenced in order to create and place subsystem envelopes.

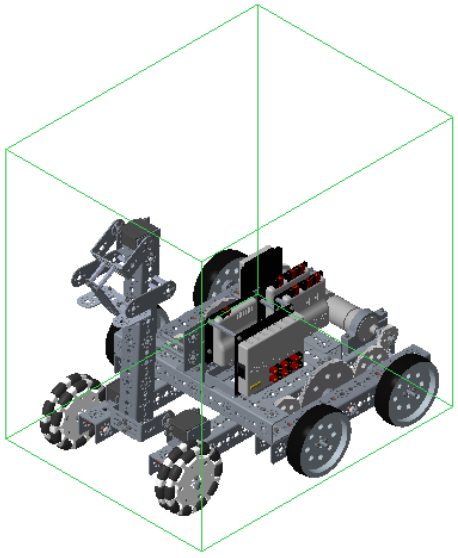


Figure 1 An envelope model establishes the dimensions of the entire system

1. From the Home tab, click **New**.
2. Select **Assembly** as the file type. Keep the defaults for the other options.
3. Name your model. In our case, we name the assembly **System_Envelope**. PTC Creo doesn't allow spaces in filenames. We use an underscore (_). Click **OK**.

The new assembly is the only file listed in the model tree. The graphic area has empty data planes. There are no parts yet. The first one we will make is the skeleton model. A skeleton model contains geometric information that defines the system-level assembly. Reference this geometry as you place parts in the assembly and make changes to it.

4. From the Model tab, click **Create**.

5. Select **Skeleton Model** as the component type. Keep the automatic filename and the default options. Click **OK**.
6. In the model tree, right-click on **SYSTEM_ENVELOPE_SKEL.PRT**. Select **Open**.
7. Select the **TOP** plane. From the Model tab, select **Sketch**.
8. From the Sketch tab, select **Center Rectangle**. Click the center of the plane. Drag your mouse to expand the rectangle. Click again to set the rectangle at its current size. Middle-click to exit the Center Rectangle tool.
9. Click outside the rectangle you just drew, and drag select the rectangle. From the Sketch tab, expand the Editing tool menu. Select **Modify**.
10. For FTC, set both dimensions to **18**. For FRC, set the length to **38** and the width to **28**.
11. Click **OK**. Click to exit the Sketch application.
12. From the Model tab, click **Extrude**.
13. Set the depth value to the maximum height constraint. For FTC, set the height to **18**. For FRC, set the height to **60**. Click .

The skeleton model is now a 3D object representing the maximum size of your robot design. You will be assembling subsystem envelopes into the system envelope model, so it would be nice to have the system envelope be transparent.

14. From the Render tab, expand the menu of colors under **Appearance Gallery**. Select a transparent color, in our case we select **ref_color138**.
15. In the model tree, select **SYSTEM_ENVELOPE_SKEL.PRT** and click the Appearance Gallery icon to set your chosen color.

Congratulations! You now have a system envelope model that represents the maximum dimensions of your robot.

16. Click **Save**.

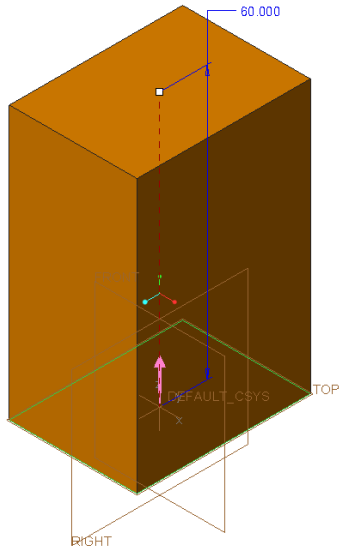


Figure 2 system envelope representing the maximum dimensions for an FRC robot

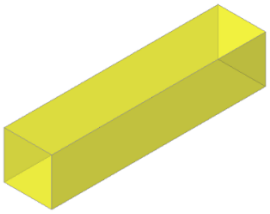
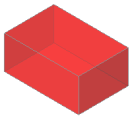
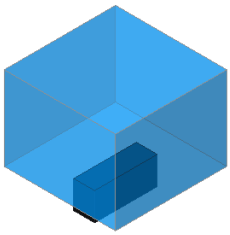
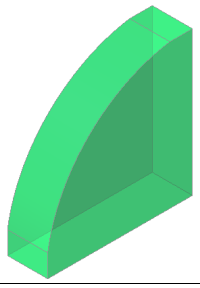
Defining the subsystems with Creo

Robots coordinate many subsystems to perform essential functions. The operation and placement of each subsystem, as well as the interactions between subsystems, must be considered in the design process.

Similar to the system envelope model, create envelope models for each subsystem. For the subsystems, however, our envelopes are parts, not assemblies. Instead of containing their own skeleton models, they reference the system envelope skeleton model. The top-down design method of referencing the system envelope as you create subsystem envelopes allows you to design each subsystem separately and integrate them together.

The geometric references will be used again in Phase II of our product development process when you assemble the detailed designs with the actual parts. The work of creating and referencing skeleton models now will end up saving you hours of work assembling and revising the more complex models later.

The System Requirements Table you created in Exercise 02 can be used to decide what subsystems are needed. As an example, we identify the following subsystems:

			
DRIVETRAIN Size: L = length of system W = 4in H = 4in Weight = 10lbs Position: Two drivetrains, one on each side of the robot	**POWER** Size: L = 6in W = 6in H = 3in Weight = 5lb Position: One attached perpendicular at the rear of each drivetrain	**ELECTRONICS** Size: L = 25in W = 25in H = 4in Weight = 10lbs Position: Centered within the robot system	**MECHANISM** Size: L = 30in W = 5in H = 5in Weight = 10lbs Position: Centered

After creating each subsystem envelope, place it in the system envelope assembly.

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