**International Lego Design Team Project Report**

**Team Members**

Justin Mendonca

Travis Nebeker

Joshua Plumb

Walter Taresh

**Background:**

The objective of this project is to work in union with the École Nationale d'Aérotechnique in Montréal, Québec to coordinate a shared design of one LEGO product with multiple assemblies and various shaped parts. The two teams will use CATIA V5 R19 or R20. This project demonstrates a global interaction work setting, where face-to-face meetings aren’t a possibility, and other means of communication must be used.

**Goals:**

* Completely model the parts of Galactic Enforcer LEGO Kit 5974
* Fully assemble kit with minimal interferences when integrated with sub-assemblies of École Nationale d'Aérotechnique team
* Produce renderings and animations showing complexity of modeling process
* Write final report explaining lessons learned from global design teams

**Organization:**

* Divided parts
  + Clear outline of what parts were shared with the other school and which were ours
  + Parts were assigned between the four of us based on difficulty and quantity
  + Parts were placed in bags based on designer and assembly
  + Instruction book left in CATIA lab for personal referencing
* Spreadsheet
  + Designated part numbers, part names, designer of part, color, and shared/unshared categories were included in spreadsheet
  + Parts that were the same piece but different colors could have been clarified and assigned appropriately. We did this for the most part, but only after we got started in the next bag. And there were shared parts that fell in this category, too.
  + Rows were color coordinated for ease of reference as to whether it was shared or not.

**Communication:**

* Weekly meetings were held via Skype with the other school on Fridays at 1:00. This was a mutually determined time that worked.
  + We didn’t meet for the Friday of our Thanksgiving break.
  + Key dimensions were mutually determined between the schools when measurements needed to be specific.
* Emails were exchanged between Michel and our group week by week.
* There was very little communication between our team and some of the other team besides Michel.

**Part Design:**

* We each were to create our own specified parts.
* Our dimensions were based off a few key, given dimensions. For other dimensions, we either measured using calipers or we would hold up pieces next to each other. It was great to use a few key bricks as tape measurers!
* Key dimensions that weren’t given were mutually decided upon.
* Certain dates were to be met to ensure progression and to keep us on the same page.
* When saving parts, we saved them as a part number along with a descriptive name.
* Strengths:
  + We were able to locate some key dimensions that weren’t given and came to common dimensions between the schools early, so that we wouldn’t have to redo all of our pieces.
  + Our team was able to come up with creative ways to design some of the more difficult and intricate pieces

**Josh**



It was difficult to figure out how to get the trigger up top to be a separate piece, since the dimensioning was so complicated, and ultimately I had to just leave as part of the same product. For this, I heavily used planes for the ribs, mirrored for the ‘+’s and ‘O’s and then just had to take my time for the back end. There is also a shaft that runs down the middle that reflected the dimensions of the missile that went through it. (Sorry, but sadly there is no spring in it.

**Travis**

In order to design the windshield correctly, it was necessary to wait until the entire “explorer” assembly was completed to obtain accurate dimensions. Once this was completed, two sketches were made on the back and bottom planes, and a spline was created connecting the two. The bottom sketch was then passed over the spline to meet the back sketch, which created the linear change of angles in the loft necessary to create a smooth transition. A first iteration of the windshield was preformed prior to assembling the “explorer”, but the dimensioning was not preformed to the correct degree of precision, making it necessary to use the method described above.

**Travis**

The chain was one of the more difficult “parts” (in actuality an assembly) that we had to create. This assembly was made by mating a series of axes in each link and each end in a manner such that the chain could be moved with respect to its constraints. When done correctly, we ended up with a chain that behaved with properties very near that of a real chain.

**Justin**

This part was challenging because of its odd shape and scarce standardized dimensions. We first made the base because it had few standardized dimensions and gave a basic shape. After the base was made we used its dimensions to extrude up to the tip. After extruding, we pocketed back into the base which gave the main part of the wing its thin features. Once that was done we created a plane above the wing and pocketed back down into the wing to give its aerodynamic shape. After that was done we extruded and pocketed the remaining holes to complete the part.

**Walter**

****The tires were parts that required rotational patterning. The basic shape of the tire is a hollowed tube (cylinder). The tread was made by drawing one tread rib on the front face, extruding it to the middle of the tire, and patterning that rib 20 times around the outside edge. I then offset the rotational pattern by one rib thickness and extruded the second set of ribs to the back face of the tire. Overall, rotational patterns save time, and can replace the mirror feature.

**Travis**

The “wing assembly” was an extremely difficult assembly to create. There was a series of four shafts that the axes of the assembly had to mate to. This left no room for error in design of the parts. To make the issue more complex, the gap between the end of the strait link and the end of the T-link had to be the correct size to accommodate the two X-wings that we received from the Canadian team. In order to do this an iterative system of equations using TK solver and estimated measurements was used.

**Travis**

One of the favorite parts for our team was the flame. This part was made by taking a photo of the actual part with an I-phone, e-mailing the photo to a team member, and uploading the photo into the sketch tracer workbench in CATIA. From this workbench an axis and scale were set to match the part, each section of the flame was traced with splines, and each spline was extruded to its proper thickness using the pad tool and mirror feature. The base was then sketched on the end of the thickest pad and extruded and a loft was made to produce the enlarged area near the base. Finally, graphic properties including color and transparency were applied to each loft and pad of the flame.

* Improvements:
  + When creating each new part, we should have clarified to all members that it was beneficial to use the “create new part” feature, and when asked to specify a part name, use the part number that LEGO specifies in the kit booklet. This would maintain a unified system between team members and teams. This became an issue during assembly as nearly all parts had to be renamed.
  + The Canadian team used this approach, thus eliminating any duplicate naming and making it easier for us to find shared parts and manipulate them out of their assembly.

**Assembly Design:**

* Renaming parts became a huge issue
* We received assemblies from the Canadians via a drop box, and had to sort through for shared parts, reapply materials, and then ensure the pieces fit.
* The Canadians were using CATIA version 5, revision 20, while our team was using version 5, revision 19. This made it necessary for the Canadian team to send all parts and assemblies via step files.
* In order to use any shared parts from the step file, we had to find the part via part number and open that part in a new window. From there we applied the correct material to the geometric solid that represented the part. This could have been avoided had both teams been on the same version and revision of CATIA.
* Strengths:
  + Surprisingly there were very few clashes between the pieces. There were some dimensions that had to be guessed on the part itself, and then altered somewhat when the assemblies were created, but it was a very simple task. This was done by measuring the necessary dimensions in the assembly once the correct position of the part was known, then having the part sent to the designer to adjust accordingly.
  + Our communication between team members during the assembly process made it quick and efficient to make all necessary changes.
  + Using the steps that LEGO recommends in the provided assembly booklets made assembling quick and efficient.
* Improvements:
  + We should have all been on the same page as to whether we should change properties or apply materials when applying colors. Ultimately, it would have been best to apply materials to each part as this would make the rendering look much nicer. Also, if a property was changed for the rendering, it wouldn’t transfer back to the part, so it would have been easier to just have done it on the part itself.
  + It would have been beneficial to have everyone use a standard system of choosing which plane to make a sketch on. The parts were created in a way such that most parts needed to be rotated in order to make necessary mates. This was a simple fix, but it became very time consuming. Some more communication up front could have alleviated this issue.
  + A few of the parts that we received from the Canadian team had minor dimensioning errors as well, most of these were likely missed due to the their use of “snaps” while assembling. Snaps provide only a geometric location for the part, and don’t take into account any interference between parts.

**Renderings:**

* Renderings were done throughout the process.
* We rendered individual pieces that were unique as well as whole assemblies.
* All Full scale Renders can be found in the teams Documentation folder under: Renders
* Animations were made of all assemblies. The can also be found in our team’s Documentation folder, under: Animations
* Examples:





* Improvements:
  + Not having material properties applied to the individual pieces became an issue here, once again. Materials had to be applied to each of the parts once again.
  + It would have been nice to leave slightly more time for animations.
* Strengths:
  + All in all, we were satisfied with how our renderings turned out.
  + We found some great background pictures and the pieces look great.
  + Having a full selection of background images before beginning our renders gave our team members lots of options, which we felt improved the quality of our renders.
  + Knowledge of lighting tools helped us to make transparent parts really glow, and colors reflect as they would if those parts were actually emitting light.
  + Our group members’ individual strengths really shined during our rendering and animation phases. Quality of the animations was low because we did not want to use up space on the T-drive. Most animations were condensed from 2 GB files to 5 MB files.

**Cooperation between Schools:**

* The Canadian team did all of the pieces for book 1 of the instruction booklets and our team did book 2.
* The Canadians also did many of the shared parts. Had we sent parts to them we would lose our part as it would be changed permanently (due to the issue of different revisions, discussed above).
* We hoped to be able to connect to their server so that parts could be shared. Ultimately, this didn’t work and we instead used a drop box.
* Through the drop box, we were able to receive their assemblies, grab shared pieces for our assemblies, add these pieces to our assemblies, and send them back to the Canadian team to be added to the final product.
* Improvements:
  + Having different versions of CATIA became a mess. It basically became a one-way production flow, where we could send parts and assemblies to them, but once this was done, they would be updated and couldn’t be sent back.
  + Language barriers became an issue as well. None of us could speak French, and only their instructor and one or two other students could speak enough English. Reading the manuals for VPN was difficult.
  + Also, we are on a semester based time frame. We believe the Canadian team attends the course for two semesters. This coupled with the time delay made it difficult to meet up online and discuss progress.
  + For questions asked, it took time to get responses due to the inherent time delay associated with e-mail based communications.
* Strengths:
  + It was good experience to learn how to cooperate under the given circumstances.
  + Everyone was very cooperative and willing to make things work for the greater good.
  + We were able to use standard dimensions in such a way that there were very few errors, making part exchange nearly a non-issue.

**Cooperation within our team:**

* Improvements:
  + Establishing standards up front would have negated a large amount of extra work. If we would have assigned the Part Names’ with a systematic approach, applied materials, had drawings based on similar planes, etc., it would make it much easier when it came time to assemble and render.
  + While we enjoyed the freedom associated with the project being open-ended, it would have been nice to know when instructors would like certain things finished, as well as have an outline for completion of specific project sections. For example, our presentation for senior snapshot day would have been much more impressive had we known the content necessary and deadline for the presentation.
* Strengths:
  + We found it easy to meet often to discuss dimensions, issues, and deadlines.
  + We were able to resolve problems with designing and assembling. (It’s much easier to say “I can’t get ‘this’ piece to fit ‘here’ by visually pointing it out, rather than saying “I can’t get ‘Part 123’ to go flush with ‘Part 456’ on the x-y plane surface above the .5 in. mark”, etc.)
  + If some parts didn’t match up right, we could get them fixed right away, and because it was all on the same server and used the same version of CATIA, the part designer could fix it, and the assembler could immediately use the corrected part.
  + We had a good flow of parts designed, assembled, rendered, etc. between us.