Intro

Iron Reign has been an active robotics team for the past eight years. We have competed in FLL, Google Lunar X Prize Challenge, and now, First Tech Challenge (FTC).

While our team originated at WB Travis Vanguard and Academy, since our members became older (such is the passage of time), we are now hosted by the School of Science and Engineering at Townview (SEM), in DISD. Despite our school being 66% economically disadvantaged and being Title 1, our school consistently ranks in the top 10 nationwide academically. Our school also has numerous other award-winning extracurricular clubs; including CX Debate, Math/Science UIL, and more. Our school employs a rigorous STEM-based curriculum, which provides our students access to specialized class schedules, such as Engineering, Computer Science, and Math, as well as paying for AP classes that our students would normally not be able to afford. The average SEM student takes at least 10 APs.

A History of Iron Reign

Iron Reign has been a team for eight years. We initially started as a First Lego League (FLL) team, plateauing in regionals every year we competed. This was usually not due to the actual "robot game" in FLL, but due to our presentations to the theme. Starting there, Iron Reign was defined as focusing on creativity and innovative designs. We also did Google's Lunar X Prize program every summer, achieving finalist status in 2011 and 2012. Upon moving to high school, we started doing FTC, as FRC was too cost-prohibitive to be parent-run.

We have been an FTC team for 6 years, advancing further and further each year. Last year, we got to the South Super Regionals, qualifying by winning the North Texas Inspire Award, which means that we cover all parts of the competition, from teamwork, to the presentation, to creativity, and to the actual game. In Georgia, the same year, we were the first alternative for Worlds if another team dropped out.

Also in FTC, we compete in the Texas UIL State Championships. For those unfamiliar with UIL, it is the main organizational committee for all public school academic and athletic events in the state of Texas. Through UIL, we helped compete in the first test program for the UIL Robotics program and since then have competed in every subsequent tournament.

Outreach

Our outreach stands out from other teams through our mode of presentation. Last year, we renovated a 90's Seaview Skyline RV, took out the "home" components, such as the bathroom and bedroom, and turned it into a mobile tech lab, so that we can bring STEM to underprivileged demographics within our community. Our RV currently holds 4 3D Printers, 30+ computers, 3 widescreen TVs, and 1 microwave. Our current curriculum consists of teaching kids 3D modelling in the back of the RV, using Google Sketchup, as it is free and available to any family with a computer. We usually help them design keychains, as they are memorable, but don't take excessive time to print on our printers. In the front, we teach kids how to use EV3 robots and teach them how to use the EV3 programming language to

compete in a sumo-bot competition. We also give advice to parents and educators on how to start FIRST teams.

To make Iron Reign's history entirely clear, we **built** the RV last year. We do not claim any credit for the actual construction of the RV; however, the goal of this year was to make our Mobile Learning Lab run year round, make it sustainable, and expand the programs to more communities around the nation. We have done all of this.

To fill and staff the RV, we have received grants from Best Buy to purchase the 3D printers and laptops, grants from non-profits such as BigThought and Dallas City of Learning to fund the building and upkeep of the RV, and staffing from BigThought and AmeriCorps, as well as our own team. The AmeriCorps staffing is especially notable, as it is a US Federal Government program to support civil service within communities. Over the summer, several of our team members became officially employed by Americorp to staff the RV full-time.

When not in outreach service, we can transform our RV into tournament mode. We have taken numerous long-distance road trips aboard our RV, with locations such as Austin, Arkansas, Oklahoma, and Florida. We substitute the laptops for a band saw and drill press, use the flat screens to program instead of teach, and bring our higher-quality personal 3D printer. At tournaments, we encourage other teams to board our RV, not only to encourage them to start their own similar programs, but also to help them with mechanical and building issues.

Iron Reign spends a large amount of time on outreach. This year alone, we have put in 680 man-hours and created 4300 individual connections to people in our community. Our goal of this outreach is to reach disadvantaged children who would not normally have the opportunity to participate in STEM programs in order to spark their interest in STEM for future learning. Some of our major outreach events include presenting at the National Science Teachers' Association Convention in Florida, hoping to inspire people in other regions to adopt our methods of outreach. We volunteered at a Microsoft youth convention to spread STEM awareness, as well as volunteering throughout our school district.

We also volunteer for FIRST. We have hosted a scrimmage for our entire school district, DISD (one of the largest school districts in the country), and have hosted a qualifier for the North Texas region in December. This qualifier had 26 teams, and we managed 30+ volunteers. We also did the entire setup and tear-down. We also instruct parents and educators on how to start a FIRST team when volunteering, as Iron Reign itself was started by parents at WB Travis.

Update (10 November 2017):

The Mobile Tech Experience program described above received a grant from Best Buy for its outstanding performance, and to fund more outreach events and upkeep of the MXP. The company that schedules MXP deployments, BigThought, also signed onto a year-round deployment schedule for the MXP.

Update #2 (22 March 2018)

BigThought, our programmatic sponsor for the Mobile Learning Lab, is helping educators and professionals in five cities across America create their own programs like the ones we run.

Date	Event	Hours	Audience
15/04/2017	Microsoft Youthspark	55	300
29/04/2017	Discover Summer Research Fair	25	250
24/06/2017	Turn Up! 2017	50	368
15/07/2017	NSTA 2017	120	400
22/07/2017	Moonday	75	400
10/08/2017	Boot Camp	18	107
14/08/2017	Red Bird Mall	6	22
09/09/17	FTC Kickoff 2017	56	0
16/09/2017	Conrad HS	32	450
23/09/2017	Stockard MS	12	250
2/10/2017	DISD Coaches' Meeting	8	20
14/10/2017	4H @ UTA	33	80
17/10/2017	Travis HS Night	8	120
07/11/2017	DISD Scrimmage	45	120
15/12/2017	DISD Qualifier	108	280
20/01/2018	DISD STEM Expo	51	400
24/03/2018	Fort Worth iMake	72	900
07/04/2018	Discover Summer PREP U	36	*
Sums		684	4367

Business and Funding

Normally, Iron Reign does not get major funding. However, this year, we have seen our funding, sponsorships, and grants increase exponentially. Currently, those include:

- BigThought - RV materials, staffing, and upkeep
- Dallas City of Learning (DCOL) – RV materials and upkeep
- Advanced Waterjet Cutting – Robot side shields and professional advice
- Best Buy – 4x3D Printers, Laptops for RV
- AmeriCorps – RV staffing
- DISD STEM - $3000 of REV parts and 2 full practice fields
- RoboRealm - $1500 of machine vision software
- Arconic - $500
- Dallas Makerspace – Access to machining tools
- DPRG – Robot assistance
- FIRST – Tournament fees
- Texas Workforce Commission – Grant

We are always seeking out new sources of funding. In the past, we have applied for prior grants by sending letters to STEM-curious companies in the Dallas area. For example, we have previously applied for a $4000 Orix grant, a STEM foundation dedicated to spreading STEM to the underserved. Also, recently, we received an additional grant from Best Buy for our distinguished service to the underprivileged within the Dallas area.

In previous years, we have lacked the ability to get significant transportation funding to get to tournaments. However, through our partnership with DISD, we have solved that problem, and when DISD is unable to provide transportation due to short notice, we can provide our own transportation due to our building of the RV.

This year, we went further in finding local businesses by looking up relevant companies that can directly benefit Iron Reign as mentors and sponsors. So far, one company has come to our aid: Advanced Waterjet Cutting. We contacted them over phone and asked about an initial meeting to see if they would sponsor us for creating side-shields and other specialty parts. They agreed immediately and we created a mentor partnership that assists us in materials research and design.

Recently, we have designed our own 3D-printed-parts kit, called REVolution. Our intention was to convert a normal REV bar, as seen on our robot, into a usable driveshaft for design flexibility. Upon finishing, we went to the REV headquarters and presented our design to them. We also have shared the basic designs on Thingiverse so that any interested FTC or FRC team can print them out and use it themselves. **Note: The main REVolution discussion is in the building section.**

Reference Business Letter

"*Dear Orix,*

Iron Reign Robotics, a robotics team of 8 years, is competing in the 2017/18 First Tech Challenge Velocity Vortex game. We are based out of the School of Science and Engineering (SEM) in Dallas which is a title one school.

The population of the public school is racially diverse and 68 percent of the students are on free-or-reduced lunch. In spite of our economic challenges, SEM is regularly considered the school that offers students the most growth in the entire district (highest effectiveness index) and is regularly in the top 10 in many national rankings. But as the second robotics team to be formed at this Dallas ISD Magnet, we are underfunded by the district and need to reach out to organizations that are investing in the long-term future of our community.

Each year we deepen our advanced robotics skills, improve our ability to organize around common team goals, and learn how to better communicate with technical professionals so that we will prepared make an impact as we continue through college and eventually join the workforce. Last year our team made it to the Regional Championship during the FTC season and then proceeded on to the UIL State Robotics Championship in Austin during the summer. This year, with your support, we are striving to make it to the 12-state super regional in Georgia and go from there to the World-wide competition in Houston.

Yet we spend a significant amount of our efforts investing in younger students outside the team. We work very hard to let young students in North Texas know about the opportunities in STEM education. We mentor students in elementary and middle schools. We regularly participate in a series of STEM outreach events to help younger students think of themselves as future scientists, engineers and technical professionals. This includes presenting at events like the Dallas Mayor's Back to School Fair, Earth Day Texas, and Moon day at the Frontiers of Flight Museum just to name a few. Last year (2015/16) our outreach involvement amounted to 400 team person-hours in service to 2,200 people. We are unaware of any other FTC team in our region that does as much outreach as we do.

This year we've stepped those numbers up to over 500 person-hours serving over 2,000 people so far just this summer. This was because we took on a project to renovate an RV to create a mobile learning laboratory for the Dallas City of Learning. Not only did we turn the interior into a mobile technical classroom with 3D printers, but many team members volunteered to teach robotics and 3D modelling and printing on board while volunteering for AmeriCorps with Big Thought this summer. The team was featured as a "Class Act" on TV channel CW33 because of this effort.

Unfortunately, time is money and the time it takes us to contribute to each of these events costs us dollars we don't have. We all love teaching young children who are interested in robotics and technology and we hope what they receive is beyond value. But we also need to raise our competitive game and new parts cost money. When jerry rigging and reusing parts unsuited for the job, we waste time that could be used to make more progress and continue the advancement of our robot. As we continuously refine our design, new parts are needed and some need to be replaced as we strive for an efficient and reliable entry. The other piece of the financial puzzle is transportation costs. This year we plan to take part in multiple competitions including out-of-state competitions in order to deepen our competitive potential and improve our chances of advancing to the next level. Competition expenses beyond the standard local track are some of the hardest expenses to fund.

We are asking for $4,000 to help us continue our journey into robotics and we hope that Orix can become a major supporter of our team while we continue to invest in the futures of many more students

Looking Back, Moving Forward

In the past, sustainability has not been a major concern of Iron Reign's. We've essentially had the same team for seven years. This year, our eighth, we've finally lost members through graduation. As a result, we've had to substantially reconsider our approach to recruitment and how to manage our changing team.

We already have another team in our school, team 3734 Imperial Robotics. **3734 is an entirely different team, with different sponsors, members, robots, journal, outreach, and codebase.** That being said, we recruit the more accomplished members of that team. The teams' relationship is most similar to the difference between a Junior Varsity team and a Varsity team.

We tend to recruit based on robotics experience, but having robotics experience alone is not a guarantee of joining our team. Iron Reign has a specific culture, and we tend to recruit people whose personalities fit our culture. We also do not accept people who only want to join robotics as a resume booster. While robotics is indeed a resume booster, and we allow every member to claim co-captain on their college applications, members of Iron Reign ought to join out of their genuine passion for robotics, not because of it getting them ahead in the rat race of college applications.

Since this year was the first year in which we lost a substantial number of our teammates, we had to learn how to effectively transfer knowledge. First, we were losing our master of 3D modelling, so we had two members, learn under his wing throughout last season. Because of that effort, they have now designed a variety of parts on our robot. For the blog and engineering journal, we had a member learn under our former head editor's tutelage how to use Jekyll, Shopify, and manage the blog. This year, we face difficulties, as we will lose our lead programmer, for next season. To combat this, two members are learning the intricacies of our codebase, which we've kept since we first started using Java.

Game Strategy

This year, we were faced with a conundrum. The central question was this – "Should we focus on scoring the cryptoboxes, relic, or jewel?" We settled on the order of Cryptobox > Relic > Jewel.

Our game strategy was based off of the fact that we could build a robot which could score one block initially, and easily score a column, giving us 40+ points right off the bat. As well, the cryptobox process is simplistic enough that we could get to the balance stone to gain even more points in the endgame, without doing any point-risky challenges such as the Relic.

When we finish the cryptobox designs and autonomous, our next goal is the Jewel. The Jewel challenge is simplistic enough that it could be done in 1-2 meetings without interfering with any other design processes. Our current planned design process is first to create an arm with a color sensor attached like most teams, but eventually we plan to remove that color sensor and identify the Jewel only by OpenCV.

Finally, our last area of focus is scoring the Relic. Scoring the Relic involves a high degree of difficulty, and the risk grows when you consider that you have to score the Relic upright in order to gain the most points. As well, building an arm that can score the Relic while still staying within the 18x18x18 size limits increases the design difficulty of the robot.

Building

This year, Iron Reign has drastically changed how it builds its parts. In previous years, we have relied on primary Tetrix parts, utilizing AndyMark parts for the drivetrain and other moving areas. However, we happened to gain access to a motherlode of REV parts, which drastically changes our designs from previous years.

The biggest change enabling innovation is our newfound use of REV rails within our robot. REV rails allow for basically unlimited mount points for parts so that we are afforded maximum flexibility in our designs, comparable to the flexibility of 3D printing.

As well, for this year's robot chassis, we have decided to take the use of REV parts even further, and use the REV Power Distribution Module and both Expansion Hubs. The reason for this change is twofold. First, we experienced significant connection and static issues last year with our robot, partially due to excess static buildup from our mecanum wheels. So far, we have not experienced any of those issues using REV modules, even though we are using the same base chassis. Second, the REV hubs allow us to add more features on to our robot, such as LED strips and extra servos that allow us to signal our team as well as create more innovative components of our robot.

We also utilize a variety of 3D printed parts on our robot. While we use less 3D printed parts than previous years that is due to the particular challenges of this year. Our parts are modelled in PTC Creo, which we obtained for free through an FTC program, and we have recently switched over from Creo V.3 to Creo V.4 so that we can use the more advanced features included in the new program. Our personal 3D printer can handle a variety of materials, and we have used nylon, ABS, Filoflex, and Ninjaflex in prior designs to fit various needs. In our current robot, we have settled on using nylon. Nylon has four qualities that make it more advantageous than other materials. First, nylon is less brittle and prone to breaking than materials such as ABS. Second, nylon achieves comparatively high print quality on our robot as compared to Filoflex and Ninjaflex. Third, nylon has enough give so that it doesn't break, but is strong enough to withstand the forces felt in everyday use of our robot. Finally, nylon can be dyed so that we can give our parts a distinguishing color, a quality that we have taken advantage of in prior seasons. As our season has progressed, we have taken a look back at various materials, and decided to consider various features of materials that we have previously neglected. In the picking up of the blocks, we needed a material that has a higher coefficient of friction than nylon, and settled on NinjaFlex to do so through a process of trial and error.

An example of these 3D printed parts are our wheel guards. In testing, our mecanum drive train tended to cut up the cryptoboxes when we drove up against them. As a result, we designed various wheel

guards and tested them. We also made mockups with various materials such as cardboard, to minimize design time and waste parts. We settled on a U-shaped design to prevent damage to the boxes and other field elements, while not sacrificing mobility. Then, to guarantee nothing went wrong, we iterated through various heights of the U-shape so that they would not cut into the mats or bump into other robots.

Iron Reign's pinnacle of design and building so far this year is our REVolution system. We were sick of stripping set screws and twisting axles, and wanted something dependable that also was reusable. Thus came the REVolution system, the purpose of which was to turn REV extrusions into driveshafts so that we could have a solid base and more adaptability in our robot. To these ends, we created a library of parts: mounts, bearing holders, and connectors so that we could use extrusions to do almost anything on our robot. Attached in our engineering journal is a complete list of parts with names, descriptions, and pictures.

Programming

Iron Reign has generated a substantial codebase over the years. Initially, Iron Reign programmed in RobotC. However, when robot phones started becoming the main form of control, we transferred our codebase into Java. We use the Android Studio IDE to code our robot.

Our most notable programming achievement has been the integration of machine vision and augmented reality libraries into our code. Currently, we use Vuforia in conjunction with OpenCV to identify and score field elements in autonomous, as well as assist in scoring elements during TeleOp. Both Vuforia and OpenCV are industrial-level technologies that we have integrated into our codebase. Vuforia in particular is currently owned by PTC, one of the sponsors of FIRST.

Another notable programming achievement is our Pose class. We use the class to determine our robot's current position on the field using trigonometric functions. While this class currently need updating for the new season, it can still be used for any small-scale operations on the field.

Design Process

Iron Reign uses two design processes in conjunction with each other to create efficient and reliable parts. First, we use the Kaizen design process, also used in industrial corporations such as Toyota. The philosophy behind Kaizen is the idea of continual improvement, that there is always some modification to each system on our robot that will make it more efficient or more reliable. As well, design competitions are a focal point of Iron Reign's design process. In these design competitions, team members choose their favored designs that all complete some field challenge, and build them individually. Upon completion of each mechanism, the designs are tested against each other, considering weight, maneuverability, reliability, and efficiency.

An example of these design processes working in conjunction is the process of designing our cryptobox intake system. One person had the idea to build an arm-style grabber seen on many current competition robots. His design, however, included shorter arms for space's sake and a more compact lift system than normal. The second person decided to build a unique conveyor-belt system which used friction to hold blocks in space and move them vertically. Through the competition, we determined that the prior design was more efficient and took up less space than the latter, so we settled on his design, adding in a linear

slide for lifting at the end of the process. Then, Kaizen comes in. Through firsthand experience in scrimmages, we learned that the grabber system isn't as reliable as we thought when first testing. So, we have designed a new grabber system that moves like the arms did previously, but also rotate with soft spikes attached to hold blocks with friction better without damaging them.

As this soft-spike system ceased to perform to our expectations, we looked to other mechanisms to pick up and deliver blocks effectively. We created a new grabber that still used the rotating systems of the soft-spike, but instead, we used custom 3D printed "octopuckers" which had a much tighter grip on the glyphs. As well, inside the gripper, we created a custom "lift" made out of NinjaFlex so that the blocks could be moved up and down internally in the gripper, eliminating our need for stacking.

Later, we further improved upon the grabber design, attaching it to a conveyor belt so that we could move glyphs all across our robot in order to score higher, using our REVolution system. This is the most ambitious use of our REVolution system yet, and we strongly encourage the reading judges to view it at the pits.

Budget

Bought:

Item	Number	Unit Price	Cumulative Price
REV Minibot Kit	2	125	250
REV Slim Batteries	2	50	100
Axles	4	10	40
Drivers	2	5	10
Nyloc Parts	4	5	20
Step Drill	2	5	10
Shaft Collars	4	7	28
Tetrix Competition Set	1	580	580
Control and Communication	2	265	530
REV Hubs	4	150	600
Motors	14	28	392
Encoder Cables	14	5	70
Soft Tiles	28	5	140
Tile Bags	2	60	120
Full Field	2	480	960
Total			3850

Wishlist:

Per Team - 6832	Unit $	# (0=bought)	Cumu. $
FTC Control and Communications Set	265	0	0
Electronics Set	150	0	0
Build System: Competition Set - Tetrix [not recommended]	580	0	0
Build System: FTC Starter Kit - REV	475	1	475
2nd REV Robotics Expansion Hub	150	1	150
Batteries	50	2	100
Batteries, Tetrix form factor	50	0	0
Servo Power Module	40	1	40
HD Hex Motor	30	4	120
NeverRest Motor	28	0	0
Lexan - 3 x 4 sheet - 3/32	87	1	87
FIRST Season Registration	275	0	0
Per School - Science and Engineering			
Game Set - Full Field	480	1	480
Game Set - Half Field	270	0	0
Game Set - Quarter Field	159	0	0
Soft Tiles Game Surface	230	1	230
Field Perimeter Kit	595	1	595
Tape Set	50	1	50