Center of robotics
Physics-Mathematics Lyceum 30

Engineering notebook for
Competition First FTC

Team PML30 –*Y*

PTC® IRISOFT

StarLine®

Saint-Petersburg, Russia
2015

Содержание

0.1 Team meetings (10.11 - 03.12)

Description: The following section contains a consequence of team meetings with short descriptions. The purpose of this is to present the elaboration of the robot in it's progress. You can find the full information about modules and program in sections "specifications for modules"and "specifications for programs"correspondingly.
Days inside section:

0.1.1 21.01.2016

Time frame: 16:30-22:00
The hooks were installed onto a mechanism for grasping the hurdle (figure 1, 2, 3).

Next, it was tested without powering the servo. The construction worked ok.

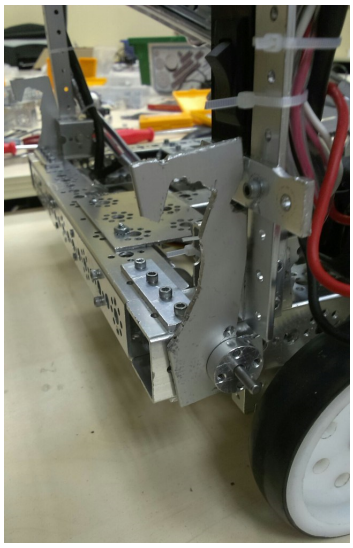


Рис. 1: Hooks rised up

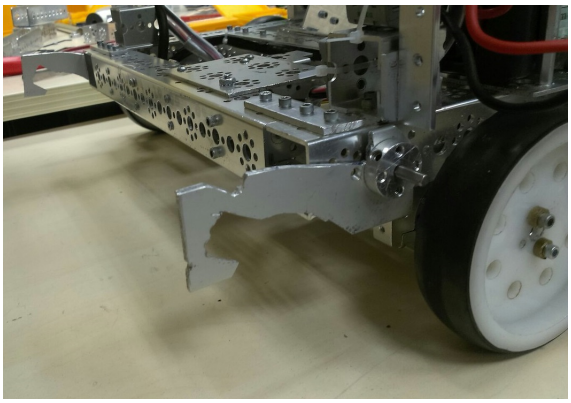


Рис. 2: Hooks turned down

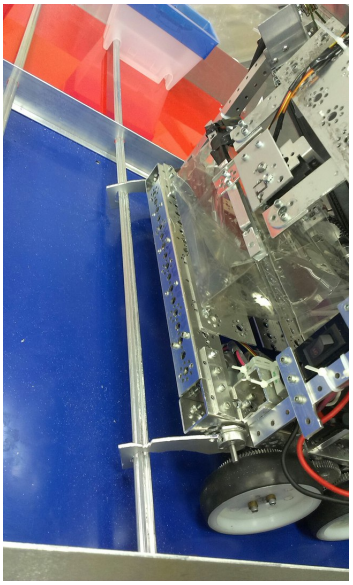


Рис. 3: How does the module works

There was found a problem in the wheel base. The holes for middle wheels were drilled out because of friction with the wheels' fixations (figure 4).

The wasted beams were replaced with new ones. In order to prevent the appearance of this problem in future, there were installed bronze collars into the holes, in which the axles of middle wheels rotate (figure 5).

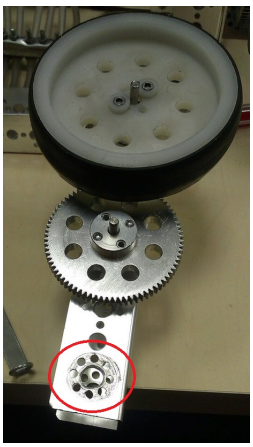


Рис. 4: Drilled out holes

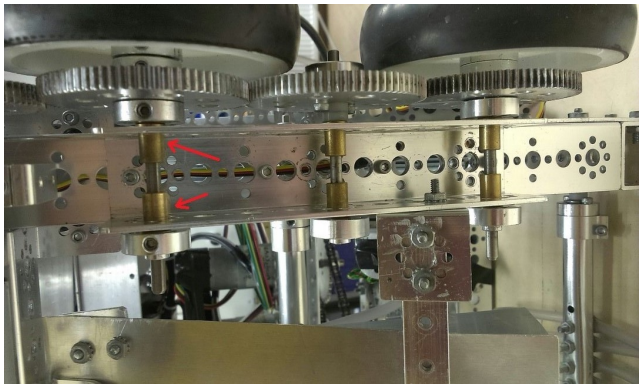


Рис. 5: The bronze collars were installed

The bucket was installed onto the robot and it's servos were connected to the controller (figure 6).

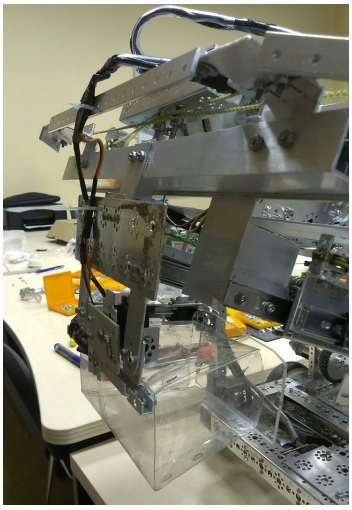


Рис. 6: Winch installed onto the carriage

0.1.2 23.01.2016 (Competition)

Time frame: 17:00-22:30

This day our community organised a private competition on our own field. There were 3 teams including ours. There were held several matches 2 vs 1, which were played according to the entire game rules. This event provided teams with an experience of a true gameplay and allowed to test all the systems of the robots. It also was a source to find mistakes in construction and understand what should be improved in it.

During the competition, there were introduced some changes of the construction.

Firstly, the servo on the mechanism for grasping the hurdle was changed from standard to continuous rotation. This was made to increase it's reliability. The continuous rotation servo doesn't keep the angle, so it doesn't break down if the external force changes this angle. It is important feature, because, when the hooks are adjusting to the hurdle, the servo can be turned by the outer force.

Secondly, the ends of the hooks were wrapped by the tape to prevent the damage of the field or other robots by the sharp corners.

Into the driving-control program there was added a function for operating the mechanism for scoring alpinists into the shelter. During the matches, this mechanism was tested.

It was decided to put the brushes on the gripper into a position, when they rotate in the same phases to find out, if this will be more effective, or not. The practice showed, that this position of brushes is inconvenient.

During the games it was found out, that the robot has plenty of areas, where the debris can get stuck, increasing our possession of it. These areas were aside the ramp for debris and under the bucket. The second area was temporarily covered by plates so as to prevent cubes from getting stuck in it.

At the mechanism for shifting the bucket it was revealed, that the cables, which pull the moving part, often get behind the pins, which causes the inability of shifting the trolley to the corner. This problem should be solved.

It was found out, that it is nit possible to collect more than 4 cubes into a bucket in game conditions. The problem was that cubes didn't settle down in a bucket as it was expected.

0.1.3 25.01.2016 (Discussion)

Time frame: 18:00-21:00

Main theme of meeting was discussing of the Saint-Petersburg competitions. Table with problems, their solutions and responsible for it team member was created.

Таблица 1: Results of discussion of Saint-Petersburg competition

Module	Problem	Solution	Responsible
Wheelbase	Too fast accelerations	Make slower accelerations in program	Andrey
Grab	Grab works bad because of parallel brushes	Make the brushes be perpendicularly	Andrey
	Cubes jam in the back of the robot	Make the solid plate in the back of robot	Andrey
Lift	Crossbars disconnect	Connect the limiters with screw, allowing them to move free	Anton
Bucket shift	Bucket skews while shifting	Check the possibility of using structural profile instead of slats	Sasha
	Slow shift	If the problem remain after fixing previous problems	Sasha
		use rollers on the mechanism	Sasha
Bucket	Shape is not optimal	Create new shape	Sasha
	Cover does not close in low position	Saw off sides of cover	Sasha
Autonomous	No autonomous	Create	Andrey
Other	Bad location of autonomous alpinists	Make mechanism indifferent to alliance colour	Andrey
	Only one hook clings	Fix it	Nikita
	Electronic is not covered	Cover	Gordey
	NXT is not mounted well, no color marking of wires	Fix it	Gordey

0.1.4 26.01.2016

Time frame: 17:00-21:00

The moving mounts for ribs on the elevator were recreated (figure 7, 8). There were applied white collars, which were sliding along the 10 cm axes. This construction had less friction and was more reliable. These details were not finished during the current meeting.

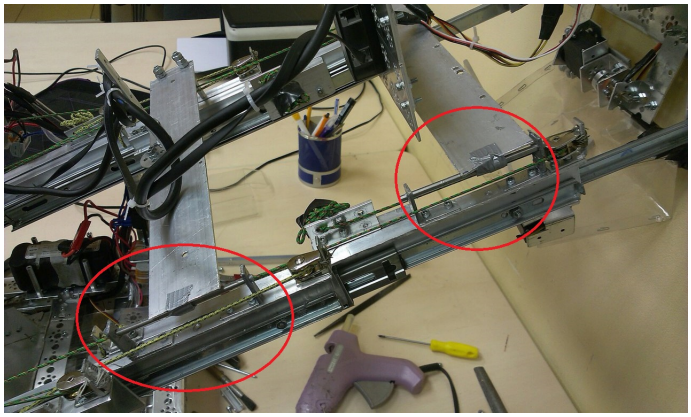


Рис. 7: Convenient movable mounts of the ribs

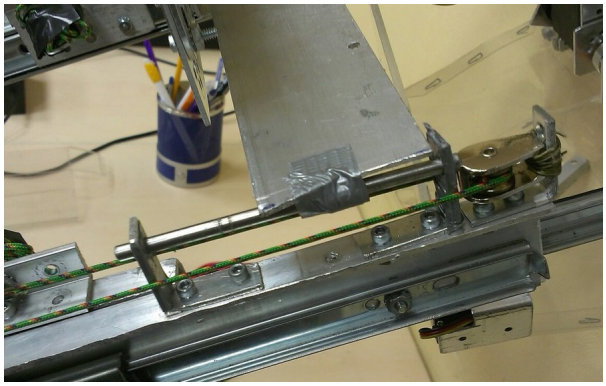


Рис. 8: The mount of the rib

After a number of tests, the brushes on the gripper were set in the most effective position.

It was created a protection from debris at the back of the robot (figure 9).

The protection of the area under the bucket from debris was recreated with a layer of PET (figure 10).

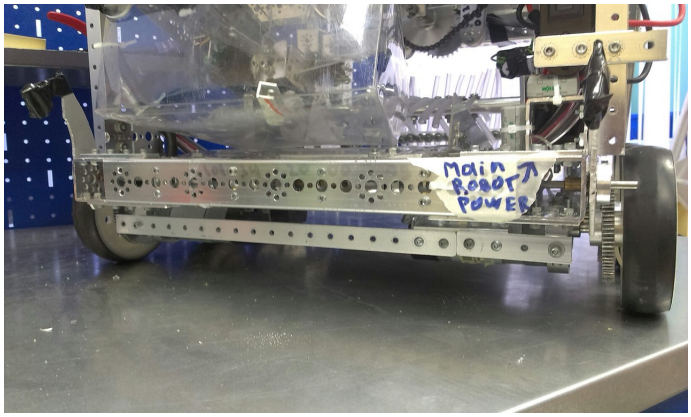


Рис. 9: Protection from debris 1

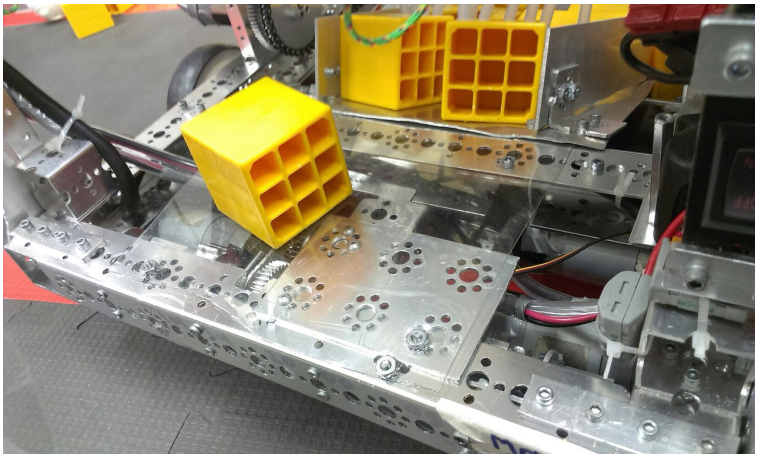


Рис. 10: Protection from debris 2

0.1.5 27.01.2016

Time frame: 19:00-21:00

It was created a surface for pushing the button on the beacon (figure 11, 12).

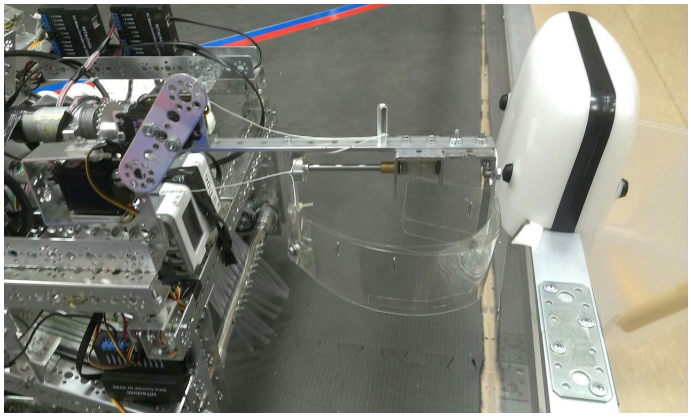


Рис. 11: The surface for pushing the button

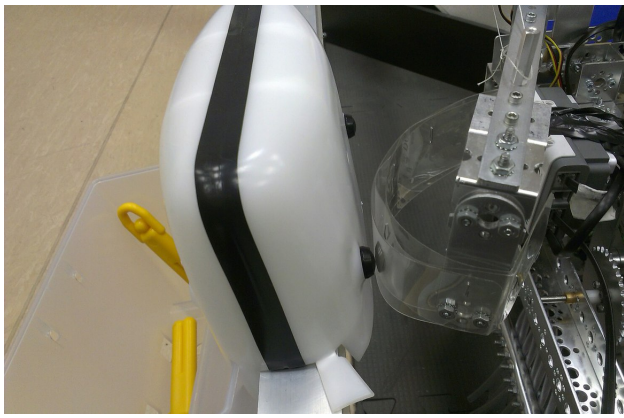


Рис. 12: How does it works

0.1.6 28.01.2016

Time frame: 17:00-22:00

It was started the development of the protection of the servos' wires on the bucket from grasping the elements of construction while shifting (figure 13).

It was also created a protection from the engagement of the cable with the axis at the mechanism for shifting the bucket (figure 14).

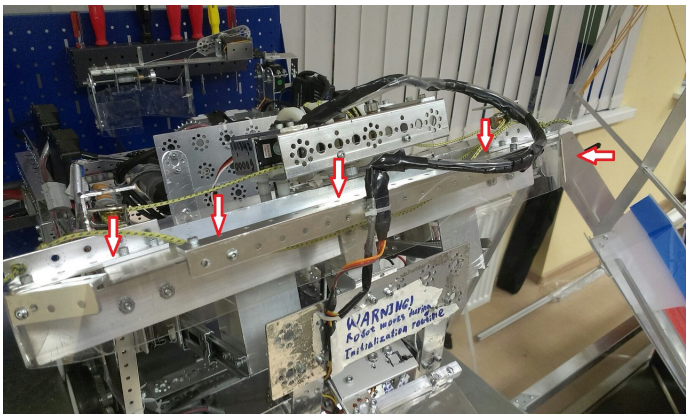


Рис. 13: Protection for wire

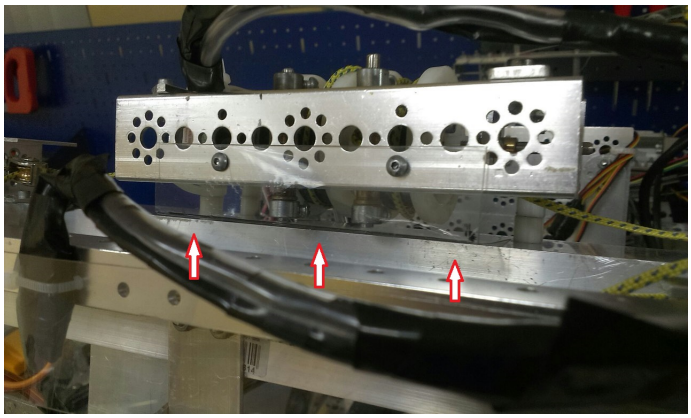


Рис. 14: Protection for cables

The mount of the second block on the elevator was strethened.

It was started the creating of the borders at the sides of a gripper, that will prevent debris from getting into the areas beyond these borders. There were taken all the needed measurements. After that, a part of these borders was cut out from PET.

0.1.7 30.01.2016

Time frame: 16:00-21:30

The borders for debris were installed at both sides of the gripper (figure 15, 16). The extension of these borders was installed at both sides of the bucket (figure 17).

The moving mounts of the ribs were finished (figure 18).

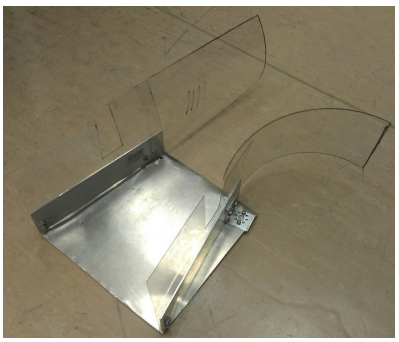


Рис. 15: Borders for debris

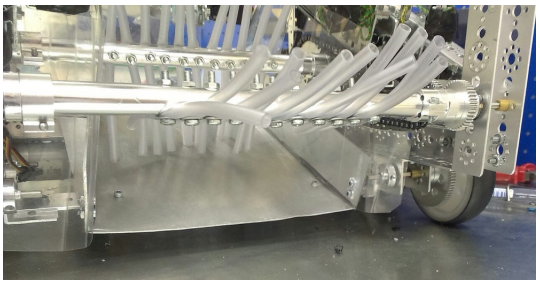


Рис. 16: Borders for debris (front)

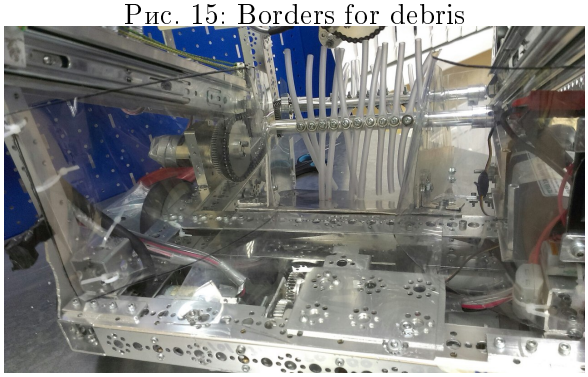


Рис. 17: Borders for debris (back)

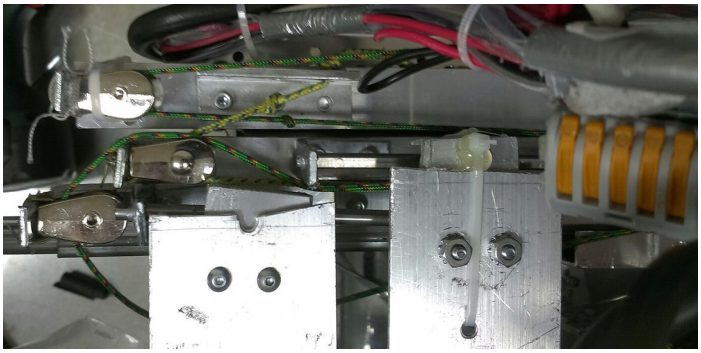


Рис. 18: The moving mounts of the ribs

The protection of the servos' wires on the bucket from grasping the elements of construction was finished. This protection will prevent wires from getting to the areas where it can get stuck (figure 19, 20).

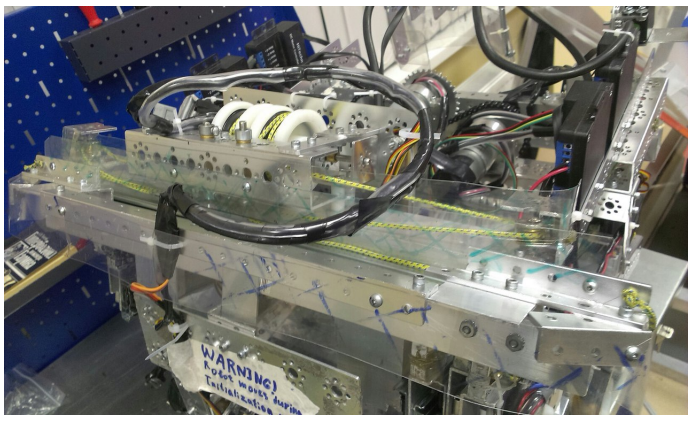


Рис. 19: Protection for wire

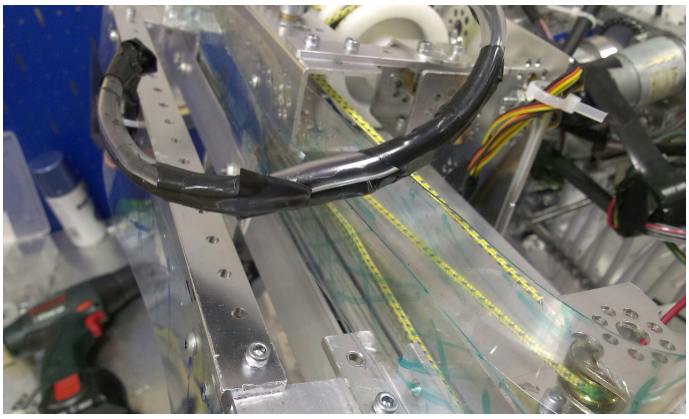


Рис. 20: How does the protection works

It was created a new bucket for debris (figure 21, 22). It's shape allowed to collect 5 cubes at once, but was more convenient, than the previous.

Рис. 21: Bucket 1

Рис. 22: Bucket 2

0.1.8 03.02.2016

Time frame: 19:00-21:30

The mechanism for grasping the hurdle was improved so as to reduce the backlash of the hooks. There were put two pieces of foam rubber which kept hooks in central positions (figure 23). However, each hook still had some free space for movement (due to softness of foam rubber), which prevented the mechanism from brakes.

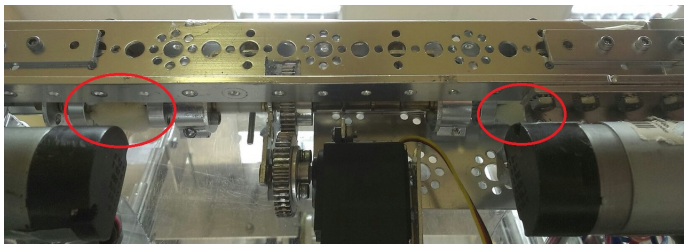


Рис. 23: Foam rubber in mechanism for grasping the hurdle

It was recreated the mount for the bucket. It was made according to the new principle of mounting the bucket, which included fixing the servo on the bucket, not on the mount for bucket.

There was installed the cover for bucket (figure 24, 25).

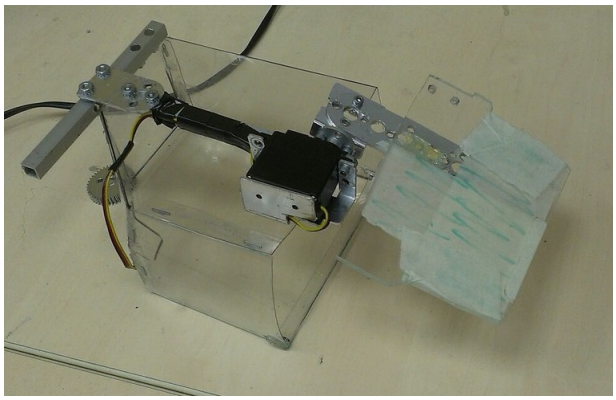


Рис. 24: Cover for bucket (opened)

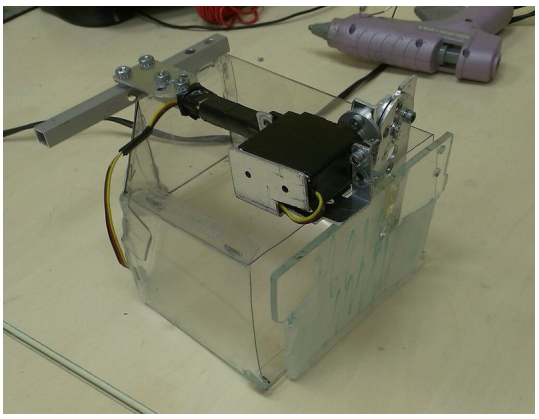


Рис. 25: Cover for bucket (closed)

0.1.9 04.02.2016

Time frame: 10:00-18:00

The cover for bucket was tested and it was found out that the axis if rotation is placed too far from the bucket, so the trajectory of its movement is too wide. However, free space inside the robot was not as much as required, so it was decided to recreate the cover (figure 26, 27).

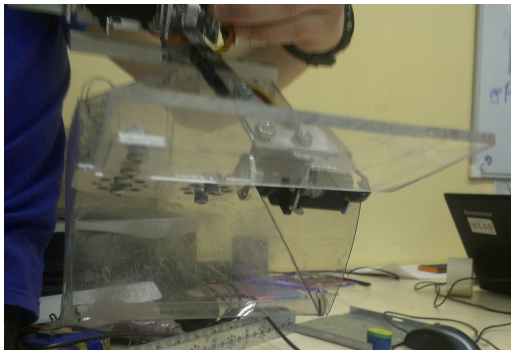


Рис. 26: Cover for bucket (opened)

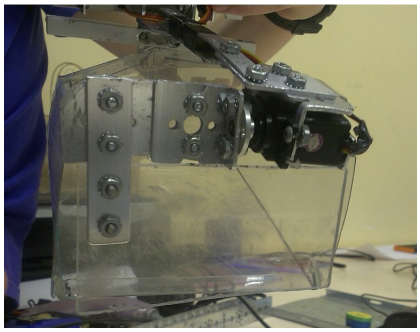


Рис. 27: Cover for bucket (opened)

After the cover was improved, the bucket was installed onto the robot (figure 28).

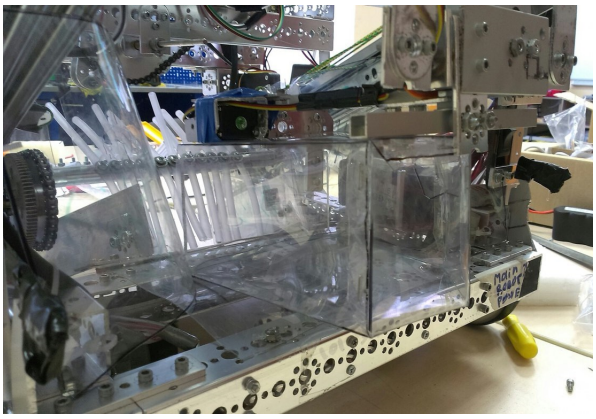


Рис. 28: Bucket fixed on the robot

0.1.10 05.02.2016

Time frame: 12:00-21:00

This day we participated in a friendly match which took place in the Nizhny Novgorod. There was total of 3 teams in this meeting, so the matches were held 1 vs 1. Our team got the second place in this competition.

Рис. 29: Match

Рис. 30: Match

During the competition there were found some problems in the robot.

The first problem was that the protection around the bucket prevented the bucket from getting inside the robot. To avoid this, the protection was adjusted to the needed dimensions. Since then the bucket could get inside the robot without difficulties.

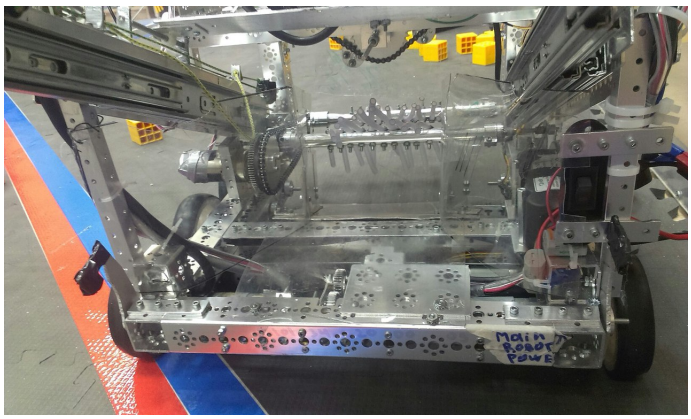


Рис. 31: Protection around the bucket was adjusted

The second problem was that the mechanism for shifting the bucket was grasping the mount which prevented if from shifting. The cause of this grasping was detected and the protection was improved.

Another problem was that the servo that operated the bucket's cover worked very poor. The problem was that the contact on the signal wire was bad. We couldn't solve this problem because of no reserve servos. However, we decided to change the servo after returning home.

0.1.11 08.02.2016

Time frame: 17:30-21:00

There was installed a sheet of PET, which was used to prevent debris from getting out of the gripper (figure 32, 33).

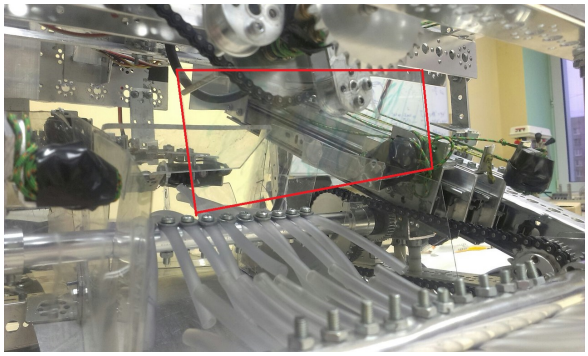


Рис. 32: Sheet of PET (front)

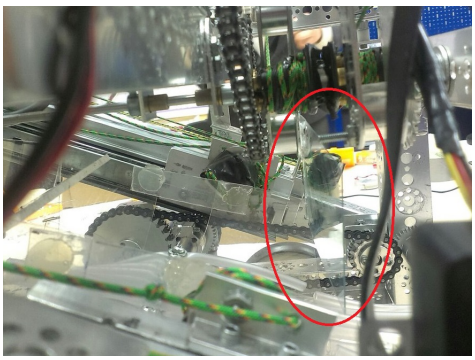


Рис. 33: Sheet of PET (side)

0.1.12 09.02.2016

Time frame: 17:30-21:30

The servo on the cover for the bucket was changed. The new servo worked OK.

It was started the assembling of the mechanism for pushing the "All Clear" signal. Today it was installed the low section of this mechanism (figure 34, 35).

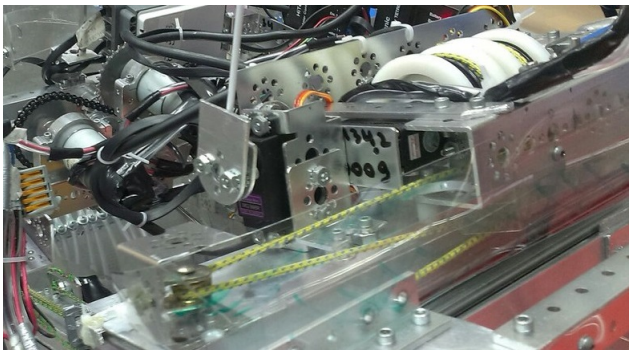


Рис. 34: Servo that rotates the section

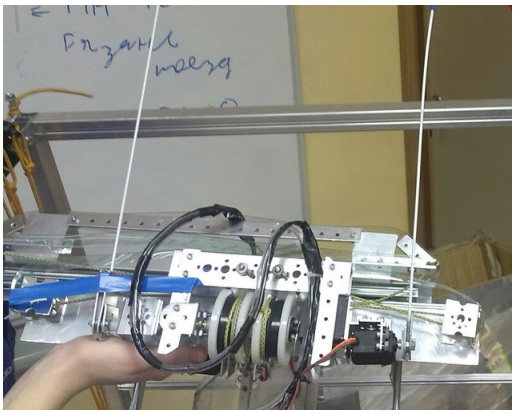


Рис. 35: Construction

0.1.13 10.02.2016

Time frame: 19:00-21:00

Today it was installed the second section of the mechanism for pushing the "All Clear" signal. Then the mechanism was tested (figure 36, 37). The result of the test was positive.

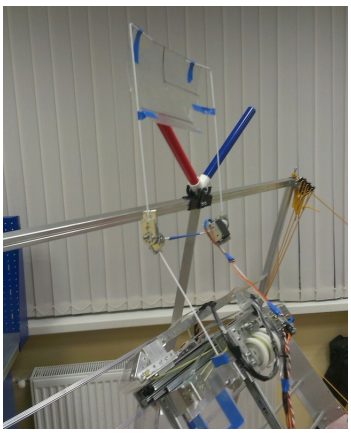


Рис. 36: How the mechanism works 1

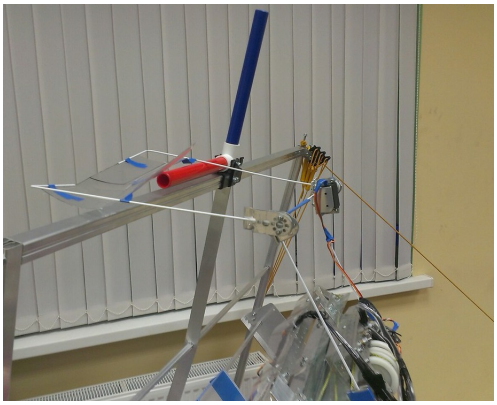


Рис. 37: How the mechanism works 2

0.1.14 12.02.2016

Time frame: 17:00-22:00

Today there were held only trainings for operators.

During the trainings the robot accidentally overturned and the bucket was broken (figure 38). However, it was quickly repaired and the trainings continued (figure 39).

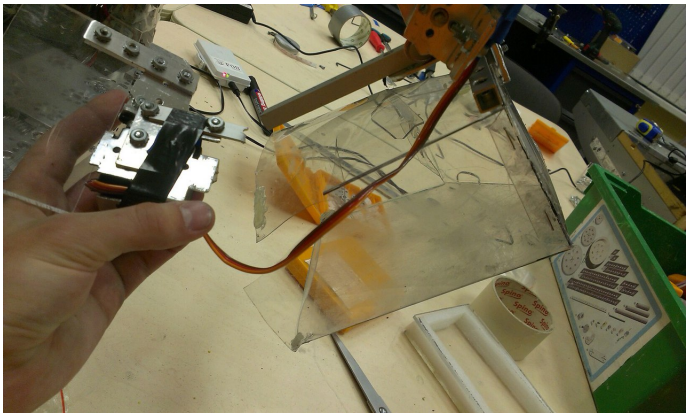


Рис. 38: Broken bucket

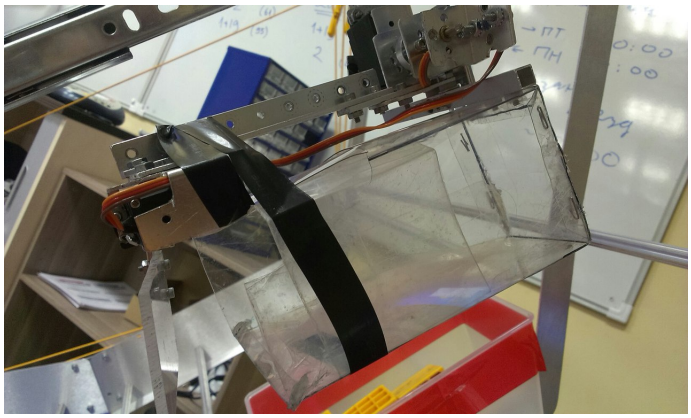


Рис. 39: Repaired bucket

0.1.15 13.02.2016

Time frame: 16:00-21:30

The axis on the winch was changed on a shorter one, which wouldn't interfere with the cover of the bucket.

The chain gears on the winch were moved closer to the motors in order to make the mechanism more reliable.

There were added new segments to the front brush in order to enlarge the collecting area.

It was also installed the protection which would prevent debris from getting under the wheels (figure 40).

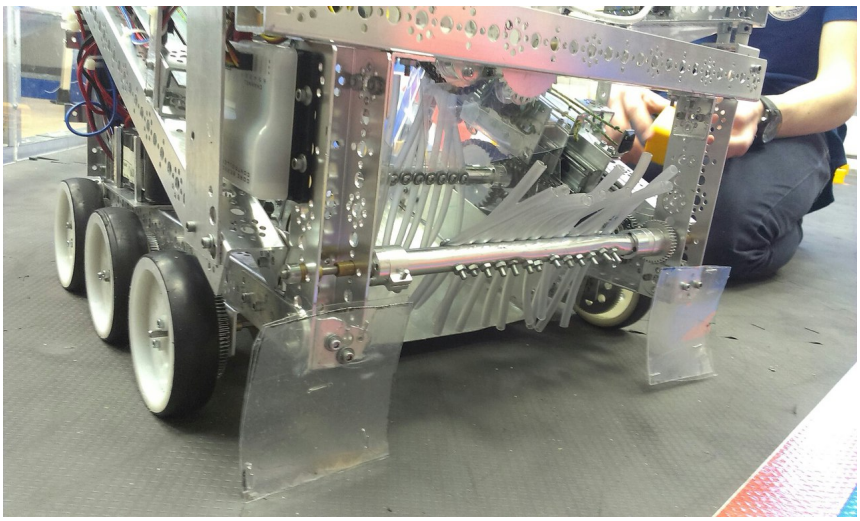


Рис. 40: Protection for wheels

0.1.16 15.02.2016

Time frame: 17:30-21:00

The NXT brick was replaced with the new system (figure 41). Then, the program was tested. The operating of motors worked without problems. However, the operating of servos was not provided.

It was installed the protection for controllers (figure 42).

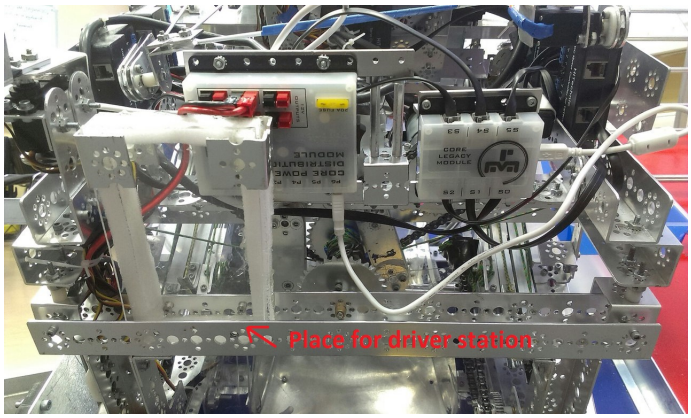


Рис. 41: New system was installed

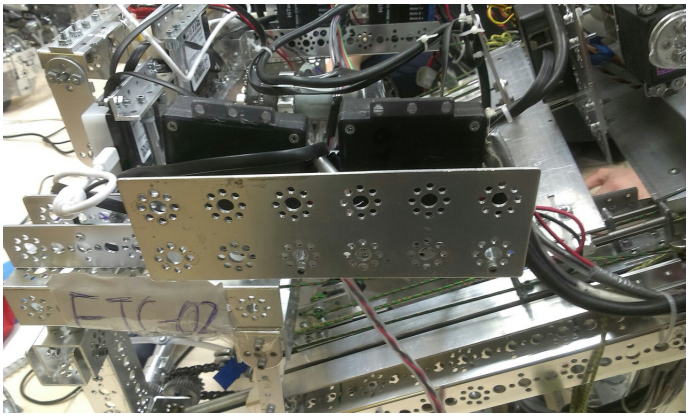


Рис. 42: Protection for controllers

0.1.17 16.02.2016

Time frame: 17:00-21:30

The program was improved so that it became possible to control both motors and servos.

After that, it was held a training for operators. At the conclusion of the training it was investigated that the program at the new system of control worked as well as the program at the NXT brick. It was also revealed that the connection between control system and the robot controlled by the "Motorola" became more stable than when the robot was controlled by the NXT.

0.1.18 17.02.2016

Time frame: 17:30-21:50

Today there were cut out pieces of plexiglass which would be installed at both sides of the robot for the protection of electronics from collisions.

It was created the decor for robot. There were printed stickers for plexiglass protection and it was decorated the mechanism for pushing the "All Clear"signal (figure 43).

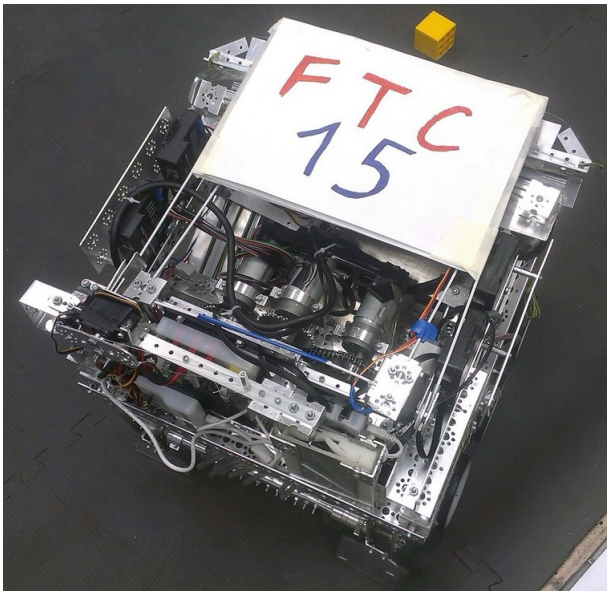


Рис. 43: Decorated mechanism for pushing the baton

0.1.19 19.02.2016

Time frame: 12:00-23:00

It was the first day of the competition . . . . There were no matches, so we had time to prepare the robot.

Firstly, the plexiglass protection was mounted to the robot and the sticker was glued on it (figure 44, 45).

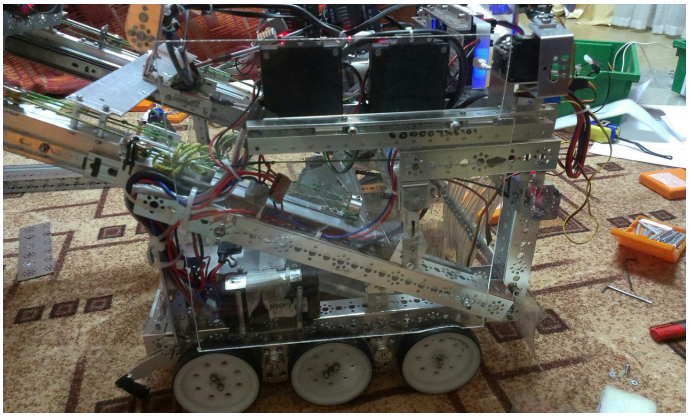


Рис. 44: Plexiglass protection

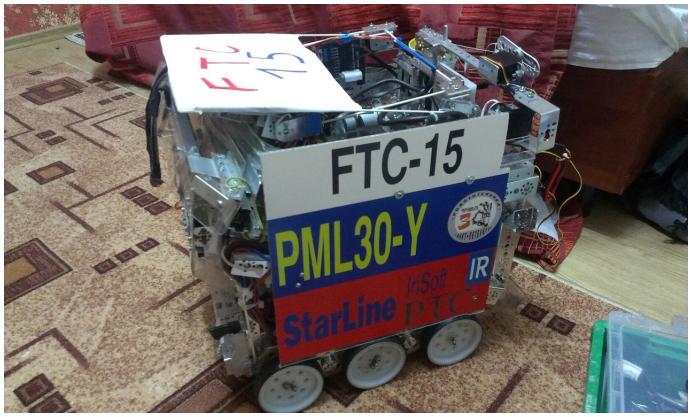


Рис. 45: Sticker on the plexiglass protection

Secondly, it was created the protection which prevented wires from the elevator from getting into the winch (figure 46).

Thirdly, it was created the protection which prevented wires from the core power module from getting into the winch (figure 47).

Рис. 46: Protection above the winch

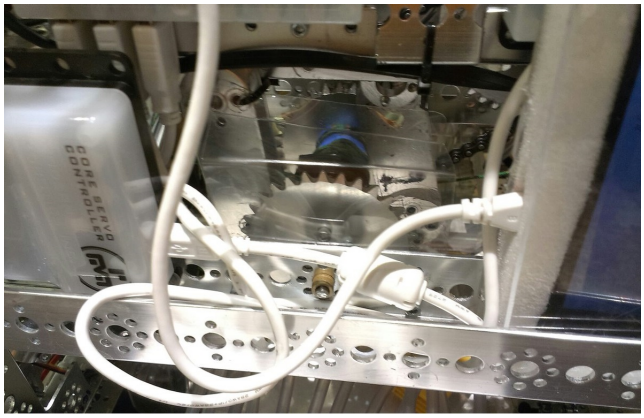


Рис. 47: Protection for wires

Lastly, it was created a device for the prevention of the engagement between the mount of the bucket and the slats (figure 48).

It was revealed that protection for wheels scratches the field when the robot attempts to climb on the mountain and this prevents robot from climbing. Furthermore, the protection touches the field while the robot is on the mountain which means that the robot in not fully supported by the ramp (figure 49). So, it was decided to remove the protection.

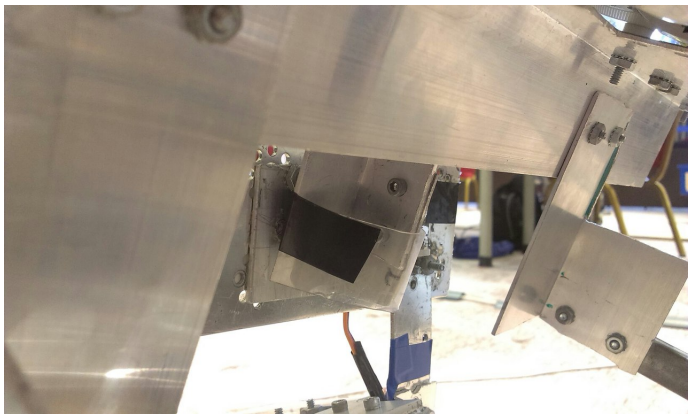


Рис. 48: Protection from the engagement

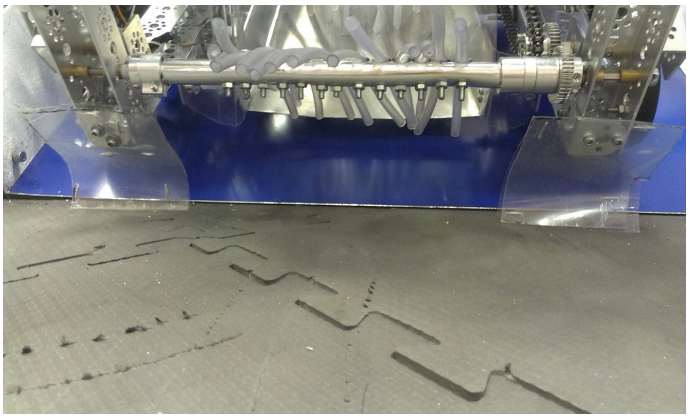


Рис. 49: The problem of the protection for wheels

0.1.20 20.02.2016

Time frame: 10:00-21:00

It was the second day of the competition. Today were held only qualification matches. Our team participated in 4 matches and we managed to win in all of them.

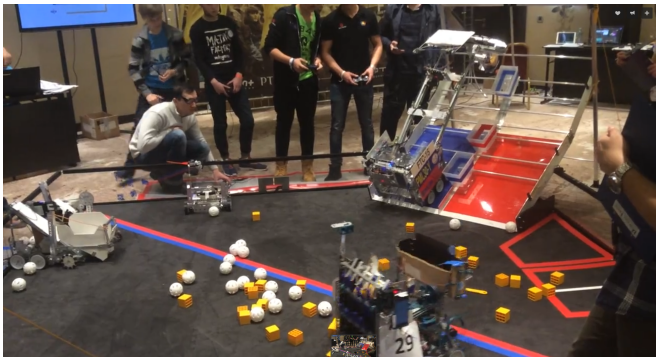


Рис. 50: Match in progress. Our robot is scoring debris into the top goal

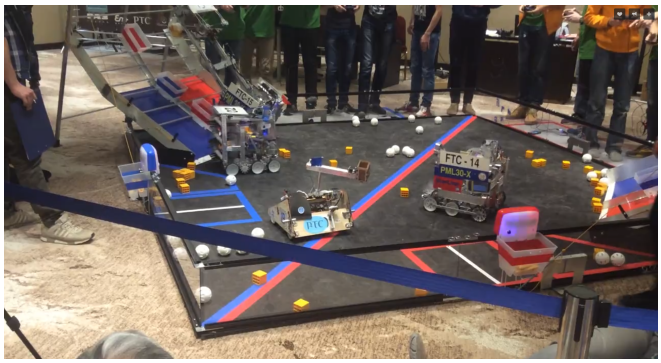


Рис. 51: Another match

0.1.21 21.02.2016

Time frame: 10:00-17:00

It was the third day of the competition. We got 2nd place at the conclusion of qualification matches, so our team was a head of a final alliance.

We won semi-final and lost final match, so we won the "Alliance-Finalist" award. We won the "Inspire Award", so we got a quotation for the FTC World Championship.

Рис. 52: Team photo with awards

0.1.22 25.02.2016

Time frame: 17:00-21:00

This day was day of discussing FTC Russia Open competitions. Problems of robot and way of their solving were discussed.

Таблица 2: Results of discussion of FTC Russia Open competitions

Problem type	Problem	Solution
Breakdowns (fatal)	Elevator's slats break	New construction of elevator
	Rope on the elevator tears	Correct stucking of rope inside slats. Study ropes
	Turning over because of high center of mass	Problem can stay
Breakdowns (can be fixed in match)	Balls stays inside the bucket	Make bucket's height more than 10cm
	Elevator pulls out because of fast movement	2nd rope for folding in
Low speed	Low speed of elevator pulling out and bucket shifting	The same speed of shifting. Bigger cylinder or plastic gears
	Cover is inside the scoring bucket	Bucket is upper in new construction
	Bucket shifts only with fully pulled out elevator	Bucket is above the elevator in new construction
	Hard to move cubes away from mountain	New module
	Cubes are throwed out by gripper	Use chquered and overlapped tubes. Find the best phase shifting of gripper's axises
	Impossible to get 5th cube without taking 6th	Problem can stay
Construction impossibility	No all clear signal turning mechanism	No solution
	Alpinists throwing is impossible in autonomous	No solution
	No pulling up	No solution

These problems seemed to be hard to solve and improve other mechanisms because of many details in construction of robot and very little space inside the robot, also it had some problems that couldn't be solved without huge changes in construction of robot.

That's why it was decided to create the robot with new construction which would be built with response to our experience received in this season. The first thing in development of new robot was creating models of all the modules. New models development tasks were spread between team members.

Таблица 3: Results of discussion of FTC Russia Open competitions

Name	Module	Tasks	Time, h
Gordey	Hooks	Model	1
		Assemble	2
		Mount	1
		Cut new (additional)	*3*
	Wheelbase	Model	4,5
		Assemble	2,5
	Debris moving away module	Model (Additional)	*3*
		Assemble (Additional)	*2*
		Total	11 *+8*
Sasha	Bucket	Model with cover	2,5
		Assemble	6
	Bucket shifting	Slats' mounting (design)	3
		Servo with coiling drum (design)	9
		Assemble	4
	Hook for pulling up (additional)	Model	*5*
		Assemble	*2*
	All clear turning mechanism (additional)	Model	*3*
		Assemble	*2*
		Total	24,5 *+12*
Nikita	Elevator	Study ropes and slats	4 + 2
		Model	4
		Assemble	4
		Mount	2
	Winch	Model	2
		Assemble	2
		Mount	1
		Total	21
Andrey	Gripper	Model	6
		Assemble	4
		Tests	2
	Autonomous button (additional)	Model	*2*
		Assemble	*2*
	Mechanism for alpinists	Model	2
		Assemble	2
	Controllers (additional)	Model	*4*
		Assemble	*4*
		Total	16 *+12*

0.1.23 27.02.2016

Time frame: 16:30-21:00

It was created a prototype of a twoside full-extracting furniture slat (figure 53). The reason was to replace the construction with 2 furniture slats used in the mechanism for shifting the bucket with 1 rail which can

move in both directions.

The ordinary 30 cm furniture slat was improved so that it could be extracted to its full length in both directions. The result of the experiment was successful.

Рис. 53: Twoside full-extracting slat (prototype)

0.1.24 29.02.2016

Time frame: 17:30-20:30

After the prototype was successfully tested, it was created the twoside full-extracting slat (40 cm, thin) which will be used in the mechanism for shifting the bucket (figure 54).

Рис. 54: Twoside full-extracting slat (original)

0.1.25 01.03.2016

Time frame: 17:30-21:30

It was held the investigation on the most convenient way of constructing the lifting mechanism. /////

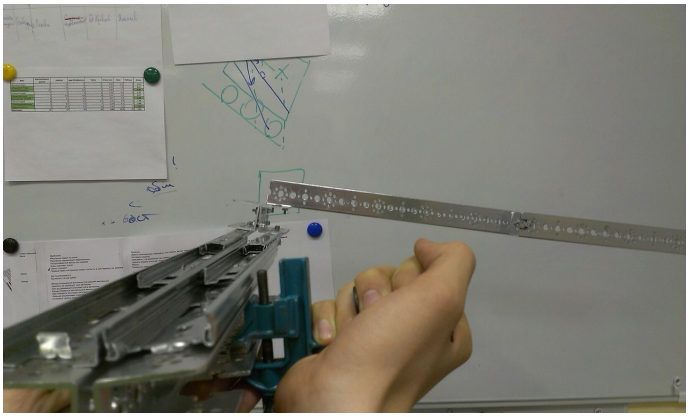


Рис. 55: Two parallel rails

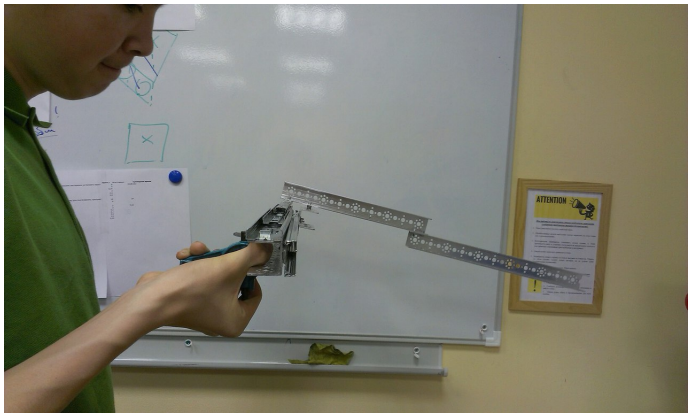


Рис. 56: One rail turned on 90° (testing right bend)

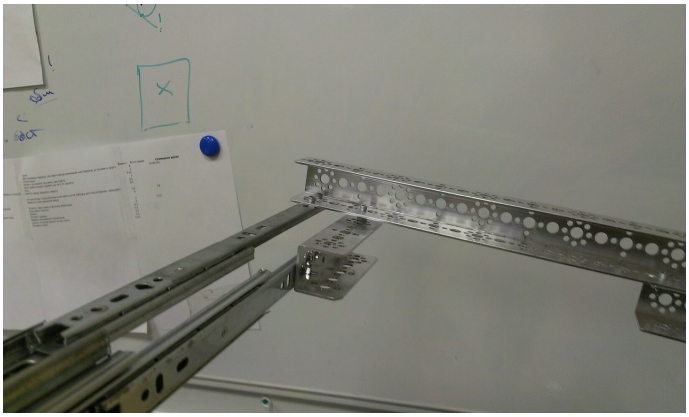


Рис. 57: One rail turned on 90°

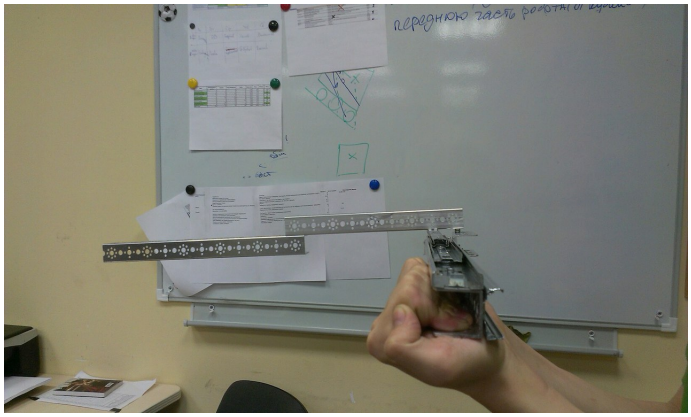


Рис. 58: One rail turned on 90° (testing left bend)

0.1.26 02.03.2016

Time frame: 19:00-21:00

Today it was found the optimal principle of building the lifting mechanism (figure 59). It was found out that if two slats are placed at the angle of $90^{c}irc$, they form the most firm construction with a good resistance against bend.

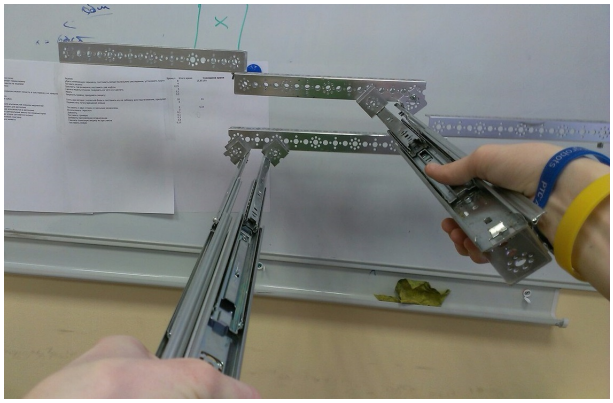


Рис. 59: Optimal construction

0.1.27 03.03.2016

Time frame: 17:00-21:30

It was assembled the prototype of the axis with coils (figure 60). This prototype was used to find the best way of connecting parts to each other with screws. It was quite difficult to calculate this in Creo Parametric.

It was also assembled a case of the winch (figure 61).

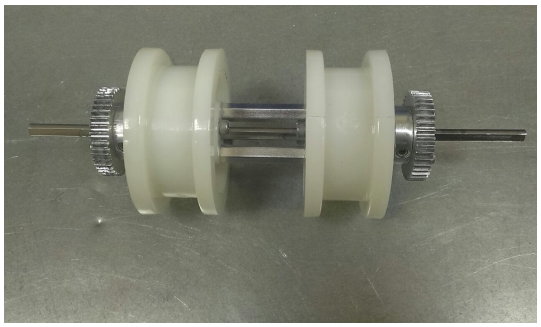


Рис. 60: The prototype of the axis with coils

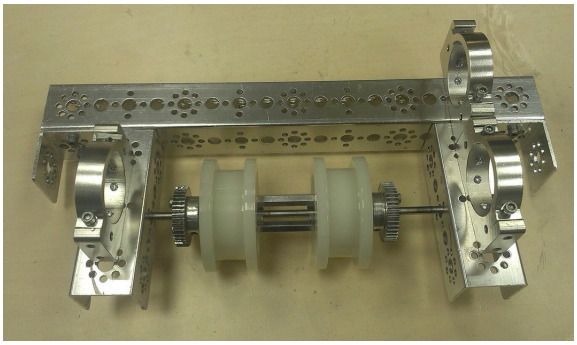


Рис. 61: Case of the winch

0.1.28 04.03.2016

Time frame: 17:00-21:00

Today it was created the cascade of furniture slats for lifting mechanism (figure 62< 63). It consisted of three pairs of 35 cm slats placed at the angle of $90^{c}irc$. The construction was created using thin slats (150 g), so the whole assembly weighed only 1,5 kg instead of 3 kg in previous lifting mechanism.

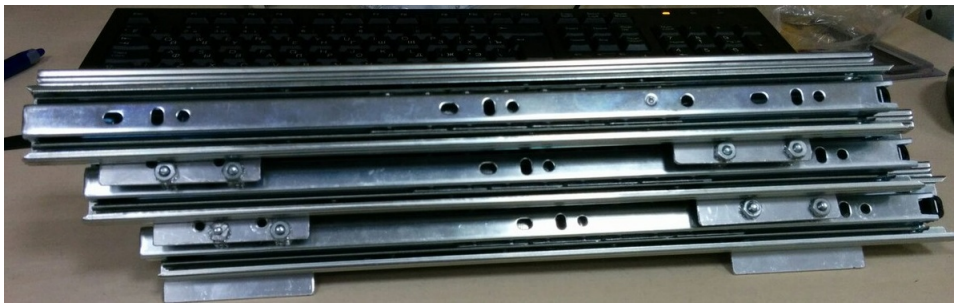


Рис. 62: Cascade of slats (side)

Рис. 63: Cascade of slats (top)

0.1.29 08.03.2016

Time frame: 12:00-21:00

The model of the gripper was finished, so it was begun the assembling of this module.

Рис. 64:

0.1.30 10.03.2016

Time frame: 17:00-21:30

Today it was held the discussion of models. Models were approved and it was started the assembling of the whole robot.

The assembling of the winch was continued (figure 65).

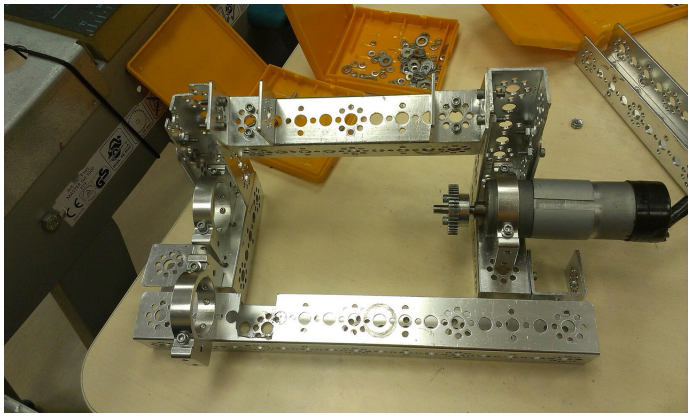


Рис. 65: Winch

0.1.31 14.03.2016

Time frame: 17:30-21:30

The parts of gripper were assembled. The gripper was prepared for installation onto the wheel base.

Рис. 66:

0.1.32 16.03.2016

Time frame: 17:30-21:30

The assembling of the winch continued. Today there were installed coils and motors. It was also created one mount for the lifting mechanism.

After that, the 41,5 cm beams were connected to the module of the winch.

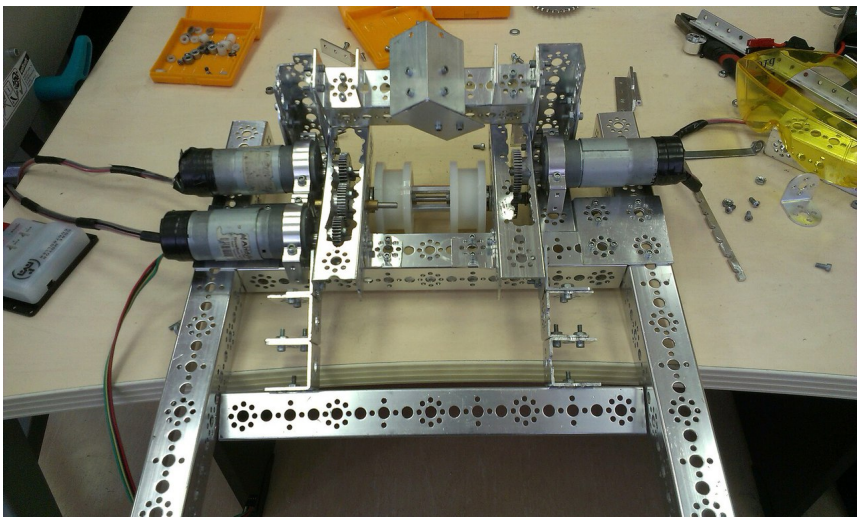


Рис. 67: Servo for shifting the bucket is fixed more reliably

0.1.33 19.03.2016

Time frame: 13:00-22:00

The wheel base was assembled. The chains were not held yet.

The gripper was connected to the 41,5 cm beams. The chains were not held yet.

It was created the second mount for the lifting mechanism and the mechanism was connected to the robot.

It was created the mount for the mechanism for shifting the bucket.

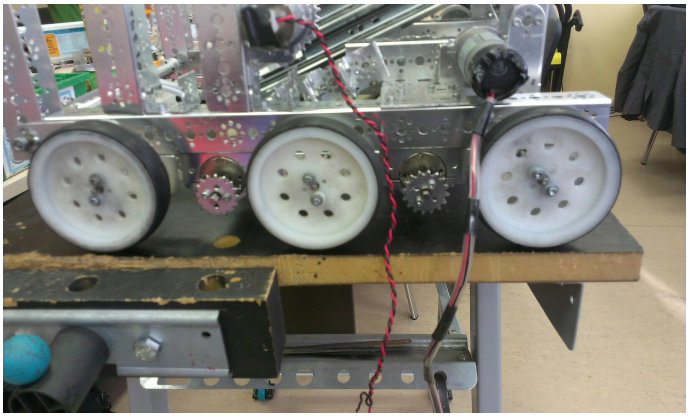


Рис. 68:

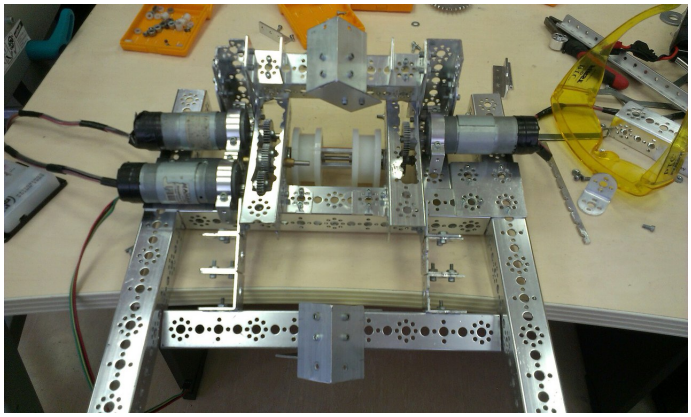


Рис. 69:

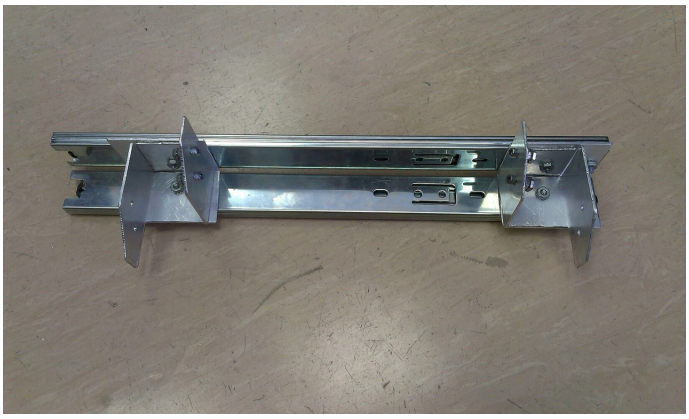


Рис. 70:

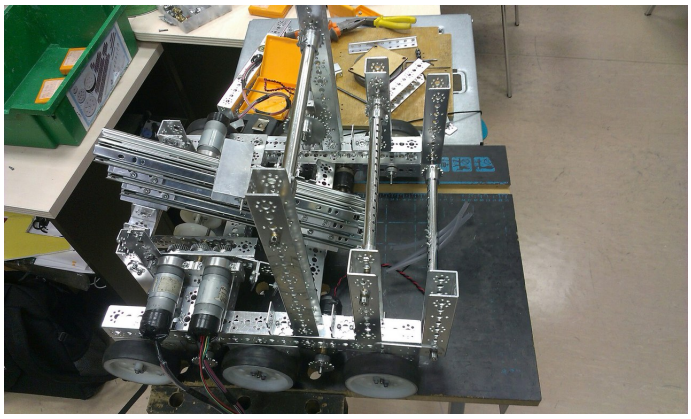
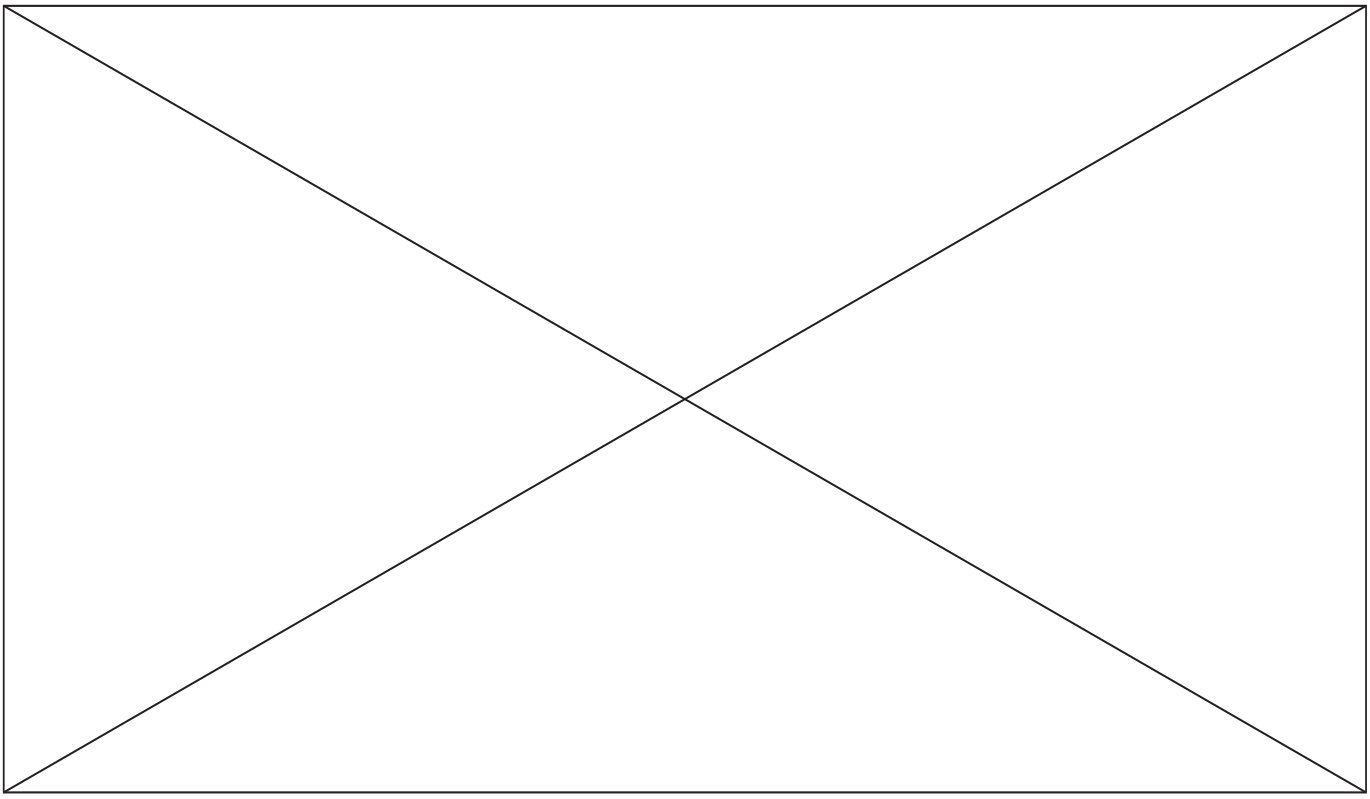


Рис. 71:



0.2 Specifications for modules

Description: This section contains detailed information the process of elaboration of each module in particular.

0.2.1 Bucket

1. The main requirements for the module were:

   - Maximum capacity: five cubes and three spheres
   - A mechanical limiter on the amount of debris in the bucket
   - A closing mechanism for the bucket
   - Delivery mechanism for putting the debris into the goals should work in both directions.

2. The first stage of development was creating the general concept of the module, its structure and method of operation. In result, was decided on the following mechanism: The bucket is shifted outside of the robot and turned 90 degrees around an axis parallel to the axis of shift; both movements are done by one servo. This allows to place the bucket opening to be parallel to the ground and increase the accuracy of debris delivery. Movement in two planes at once is accomplished through sloped guide rails, which turn the beams with the bucket during their sideways movement. To prevent premature release of debris from the bucket, the bucket opening will be closed.

3. The next step was developing the closing mechanism. To minimize the load on the servo completing the turning movement, the center of mass of the module has to be situated as close as possible to the mounting point on the lifting mechanism. Thus, the following system was developed:

   - On the beam which is mounted to the lifting mechanism, is installed a reel with twine.
   - The twine is fixed in such a way that when the reel turns in one direction, one of the ends is pulled taut while the other slacks, and vice versa.
   - The twine wraps around several fixed blocks along all the beams which support the bucket.
   - Above the bucket opening there is another axis with another reel identical to the first, and the surface which blocks the opening.

   This allows to open and close the bucket without adding any additional significant load on the servo which turns it. To make sure that such a mechanism for transmitting rotational movement indeed works, a simplified model was assembled. The results of our tests showed that this transmission is operable, but the angle between the extreme positions is slightly more than 135 degrees, rather than 180 degrees, but this is still enough to complete the task.

4. After that the parameters of the guiding rails (slope relative to the vertical direction, maximum height) were calculated depending on where they are mounted:

5. The bucket, mounted on the beams, which in turn are mounted on the slats are in point A and move together. CB can rotate around point B. DE is the maximum height of the guiding rails. Position 1: the bucket is lying on the ground and collecting debris. Position 2: the bucket is perpendicular to the ground and can deliver the debris to the goals. The needed ratios can be found from the easily derived formula:

6. At the time the above process was completed, the qualification rounds were not far away, and so was decided to temporarily use two servos for shifting and turning the bucket, since the structure of the module would become significantly simpler and would require less time to complete. Were connected two slats in such a way that their uppermost part could move in both directions. After that on one of

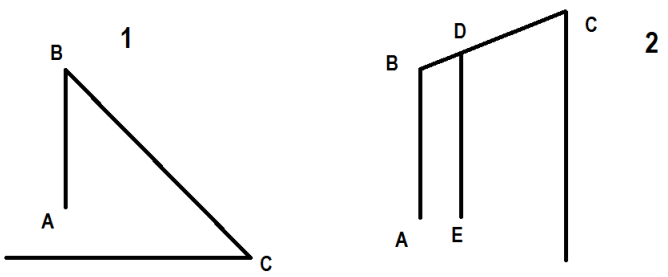


Рис. 72: Side view of beams onto which the bucket is mounted

the ends of the slats were added limiters that depending on their position do not let one of the slats move. This does not prevent the robot from working properly, as we know our alliance before the match and thus in which direction we need to extend the bucket. This means we can adjust the limiters before the match. (Note: in the figure both limiters are set to the closed position, in which neither slat can

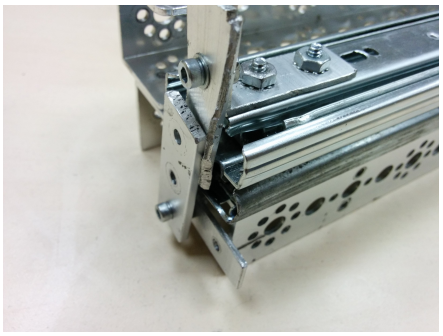


Рис. 73: Structure of limiters

move; during the game itself one of the limiters will be set in the open position).

7. Then the servo with a reel for the twine moving the slats was fixed on. Blocks were attached to the ends of the fixed beams and wound the twine around them; the ends of the twine are tied to the ends of the slats, which allows them to move as needed. The servo direction of rotation defines the direction of movement of the slats and the bucket.

8. After that was come up, tested and made another, less complicated, trapezoidal bucket with the opened part smaller than closed. The construction of the guides on the top of bucket would make debris fall in sequence 2-2-1 from the bottom, that way the scoring goals will hold maximum number of debris.

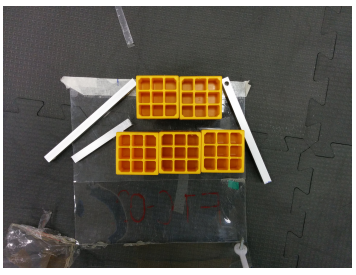


Рис. 74: Structure of guides

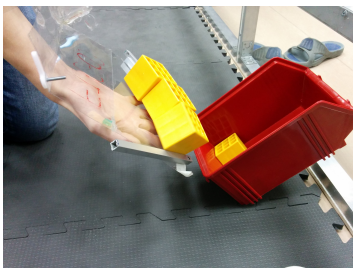


Рис. 75: Process of guides testing

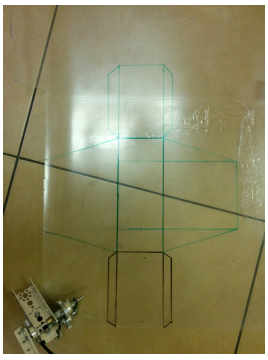


Рис. 76: Marking of bucket

Tests showed that guides work well, so was decided to use them in construction of bucket. The pair of front makes debris fall to the scoring goals more accurately, the asymmetric guide slows one debris to make all the debris fall as 2-2-1, not 2-3.

9. After that was stretched the line to move the slats. Servos for moving the slats and turning the bucket were placed on the slats.

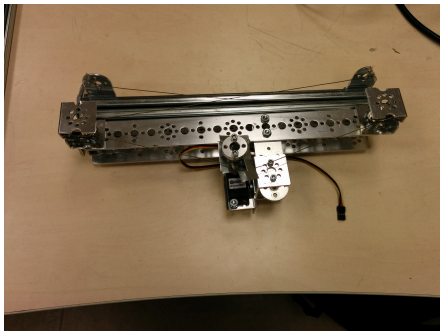


Рис. 77: Construction of line and pulling it servo

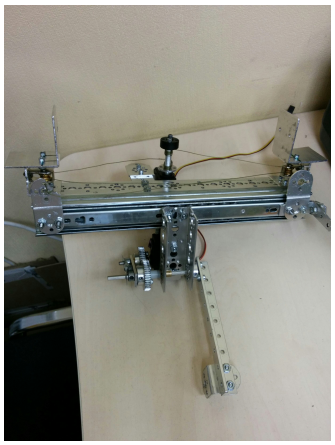


Рис. 78: Final construction of the slats

10. Next done part of module is closing mechanism. The difficulty in it is that axis of servo has to be as close as possible to the front-top edge of bucket.

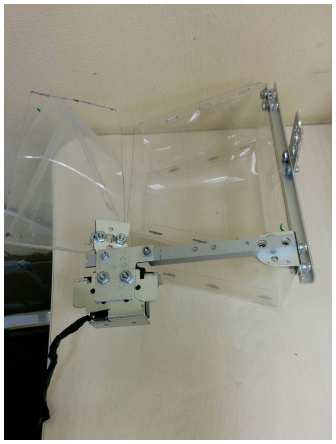


Рис. 79: Final construction of the bucket with closing mechanism

11. After that bucket was installed on bracings on the slats. Then all the module was mounted on the lifting mechanism. It was done in the way to make the bucket turning axis as low as possible. It would make the volume, used by bucket less, because with that place of the bucket it was necessary to turn it while lifting because otherwise bucket intersected with other parts of robot while lifting. So the lower axis made the radius of bucket turning less and reduced the capacity on the servo by shortening the shoulder of buckets weight. By the time it was done, the first competitions had almost started so the slats weren't mounted on the lift because of time troubles.

12. After the end of competitions slats were replaced by longer ones (40 cm instead of 35) to make bucket shifting completely out of robot theoretically possible. Also the shifting servo was changed to faster and

more powerful servo in order to make bucket shifting faster and more reliability. Then possible work process of bucket was estimated and it turned that fast lifting was impossible. It was so because the bucket was to be turned in case not to intersect with other parts of robot to be lifted. And generally bucket was close to catch parts of robot while moving from front of robot to its end during the lifting. To solve these problems was decided to place the bucket into end of the robot above two beams. It would make lifting easier because bucket would move inside robots projection much less time than before, also it is easier to transport debris throw the robot than to transport the bucket.

13. Then the slats were mounted on this lift in the way to place bucket in the end of robot. The next problem was not much space so the beam, on which the bucket was mounted intersected with lifts slats while shifting. So the mount of the bucket was changed. With that construction servo was turning with the bucket. It made the non-intersection beam possible. After that bucket was mounted on the sift mechanism without any intersections, so the problem was solved.

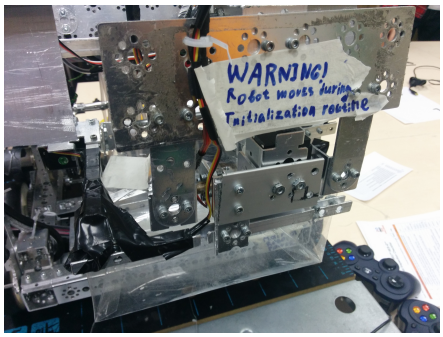


Рис. 80: Construction of bucket

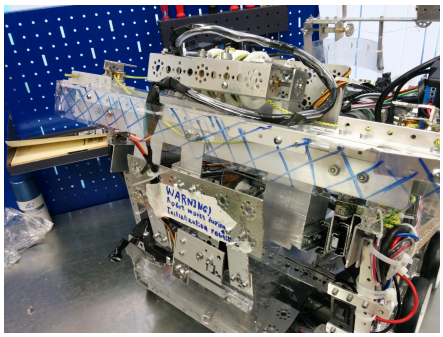


Рис. 81: The bucket mounted on robot

14. The next step was testing bucket and the whole robot. In the process of it was found two problems: the closing mechanism was able to work only when the bucked was a bit lifted and bucket couldn't hold 5 cubes, caught by grab mechanism. First problem was solved by cutting sides of partition, closing bucket. The second problem weren't solved by adding guides to move first cube sideways (grab couldn't move the cube so). Because of it was decided to change the shape of bucket.

15. After that the new shape was devised.

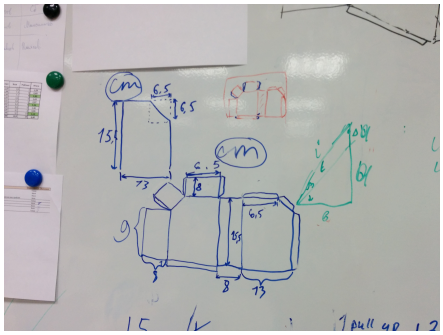


Рис. 82: Shape and scan of the bucket

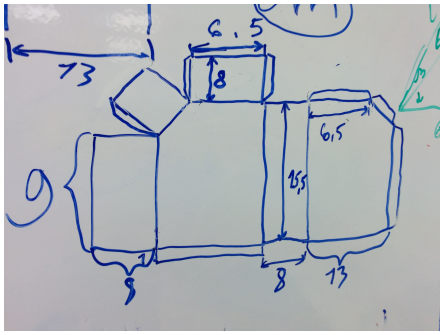


Рис. 83: Closer view of the scan

This shape was chosen because:

- It was easier to fill by the gripper
- It was big enough to hold 5 cubes

- It was not enough spacious for 6 cubes
- It has output hole with width of 2 cubes and that made cube falling vore direct and allows to score cubes.

16. Then the new bucket was marked and cut from a sheet of plastic (the same was used for the first bucket). Next, bucket was assembled and tested (not on robot). Tests showed that bucket was able to hold 5 cubes and score them directly to the high scoring bucket.

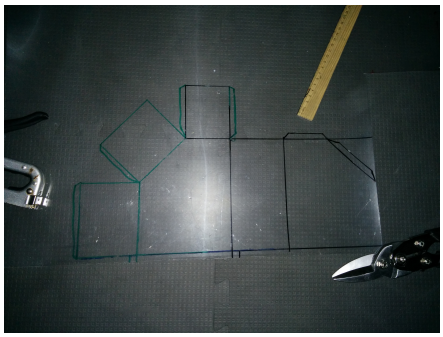


Рис. 84: Marking of bucket on the plastic sheet

Рис. 85: Fully assembled bucket with cubes inside

17. After that was made protection for wires that could get into slats and break there. Also was made protection for rope of shifting mechanism that could catch on parts of robot because of which shifting stopped. Both protections are plastic strips.

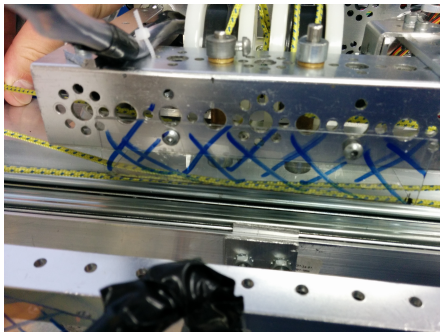


Рис. 86: Protection of rope

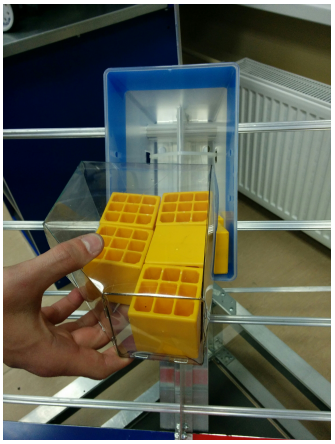


Рис. 87: Test of new bucket

18. Then competitions FTC Russia Open in Sochi started and no more upgrades were done but the cutting off part of cover of the bucket. It was made in order to make cover not be inside the scoring goal while dropping debris into it. This made process of scoring much more fast, safety and easy for operators.

19. After the competitions was made a decision on the creating new structure of robot and fully rebuilding it with making models of modules in CREO first. In new construction bucket wouldn't turn and had to have 2 holes: for debris entering on the top and for their falling on the bottom. It had to be spacious enough to let balls go throw it freely. New shifting mechanism had to be the same with some new features: two directions slat instead of two slats, lighter and easier mechanism of coiling the rope.

20. In the process of designing new shifting mechanism was decided to use wheel and rope from jalousie. It makes all mechanism much smaller and lighter. Servo had to be the same but with the gear to make

shifting faster. it was decided to use lego gears because of their small weight and easy mounting.

21. The model of shifting mechanism with 1 slat was made in CREO.

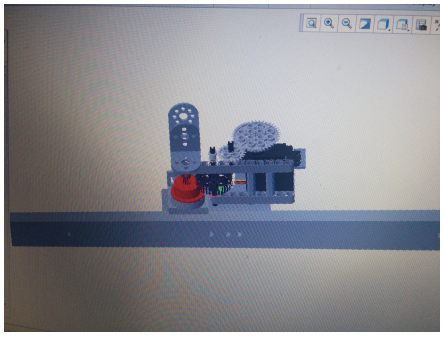


Рис. 88: Shifting mechanism in CREO

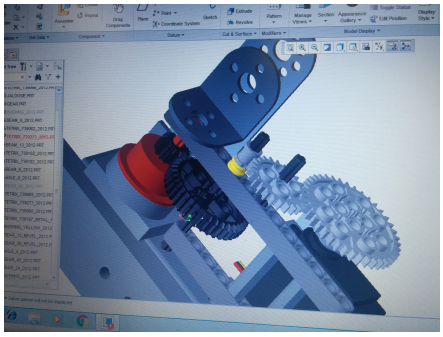


Рис. 89: Shifting mechanism in CREO