Festo **LOGISTICS COMPETITION 2011**

RULEBOOK

Document information

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Preamble

This set of rules provides a precise definition of the competition environment.
The rulebook ensures the same and fair circumstances for all participants, it however is not meant to dictate or suggest the way of approach to fulfill the task.
It furthermore concentrates on defining all necessary variables and necessities and is not meant to visualize the competition itself.
For general information about the idea of this competition, please refer to the information booklet supplied at the Festo Didactic homepage.
Technical information about the Robotino® platform and details to components used in the construction of the competition area are combined in the engineering reference and try the powerful RoboCup Simulator which are both supplied at the link above, too.

With the experience and feedback from RoboCup 2010 this year's rulebook takes a step back to the core task of any logistic process, keeping the focus on the very soul of this competition. We therefore encourage all participants to find a solution to the task circumscribed within the following pages and want to remind all teams that this competition will evolve over the next years with a task matching the participant's know-how. The vision behind future developments will always be to bring this simulation as close to the real industrial process as possible.

Finally, no rulebook is perfect. Feel obliged to inform us about issues you like to discuss or gaps that might have an impact on the competition, so we can keep the necessity for rule discussions at the RoboCup event to a minimum. We are open for all kinds of suggestions; the set of rules will be fixed at 01/01/2011 and revised in April 2011 once the German Open are over. We also encourage all interested teams to apply as a member of the Organization Committee (OC) for both the German Open and the RoboCup 2011 in Istanbul.

The fastest way to contact the TOC is via e-mail: robocup@festo.com

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Legend:

- ☐ Unchanged rule
- ✖ Outdated rule, will be remade next year or dropped from the rulebook.
- Postponed rule, will be implemented next year
- Brand new or updated rule, that applies this year.

1 Agreements & Regulations

The Festo Logistics Competition follows a certain design philosophy. All teams are obliged to use the Robotino® robotic system of Festo Didactic Gmbh & Co. KG with certain freedoms and limitations. The usage of both revisions, namely 2009 and 2010 are in order, see chapter 4 for details.

2 The Task –"A challenge of precision within a flexible deployment system"

The FLC aims to simulate autonomous guided vehicles (AGV). In opposition to regular automatic guided vehicles, a team, consisting of a maximum of three Robotinos®, shall complete the following task without a control station or human interference as successful as possible competing with a second team against the clock.

The main task is a 3-staged production cycle with self crafted intermediate products and the transport of the final product to the designated zone. This is the genuine goal and will be rewarded considerably higher than partial fulfillment of the task.
Although the distribution and utilization process of the different machine types is known to the teams, the reference which production machine is of which machine type is not. Therefore, a part of the task is to discover the machine types of as many machines as suitable. In order to complete the production cycle, it is required to produce the three subassemblies step-by-step. The factory's capacity theoretically allows production of resources for two products at the same time. The whole factory area can be used as an intermediate storage.
Finally, the successfully assembled product has to be delivered to the correct delivery gate and get dismounted into its delivery slot.
The factory area has to be treated in the best possible way. Theoretical damage will result in minor punishment. This includes machines as well as pallet carriers.

2.1 Production portfolio

Subassembly	Deployable	Prerequisites	Result
S0	M1, M2, M3, DG	-	S1 or consumed
S1	M2, M3, DG	S0	S2 or consumed
S2	M3, DG	S0, S1	P
P	Delivery Gate	S0,S1, S2	
Express Good	M1	-	Finished Express Good

2.1.1 The production table

The table above shows the production table concerning the main challenge; the three staged production process as well as the express good challenge. The main challenge can be repeated as long as enough pallet carriers can be provided to complete the cycle. The different machine types are specified in section 3.3

2.1.2 Express good

The express good challenge will start as soon a pallet carrier has been inserted into the express good slot by the referee. The challenge requires a fast paced processing and delivery within the time requested. The challenge also requires prior knowledge concerning the machine distribution.

3 Competition Area

The point of origin for each statement within this rulebook that uses relative coordinates is the bottom left corner of the competition area namely the corner near the recycling unit to the left of the outgoing goods area. All indicated sizes of mark-ups are to be considered outside dimensions.

The **competition area** is a 5.6m * 5.6m large arena with several RFID-mounted machines, mark-ups, a stock of raw-material and a delivery zone. It is surrounded by boards, 0.5 m of height to reduce object interference from outside the area. The default width for mark-ups is 19 mm, the default color is black.

The **factory area** spans across 5.6 m x 4.8 m. There are two boundaries, set by two mark-ups, 0.4 m from the top and bottom borders of the competition area. The factory area is joined by two opposing 0.4 m x 1.0 m zones at the top and bottom middle. The top zone is painted “blue” marking the input store area with the express good insertion point to the right. The insertion point is 0.6 m of width with the insertion slot in its middle. This spot is a 0.1 m times 0.1 m empty square that will be equipped with a pallet carrier to start the express good challenge.
The space between the recycling unit and the express good insertion point, as well as the space to the left of the input store area is called **robot insertion area**.

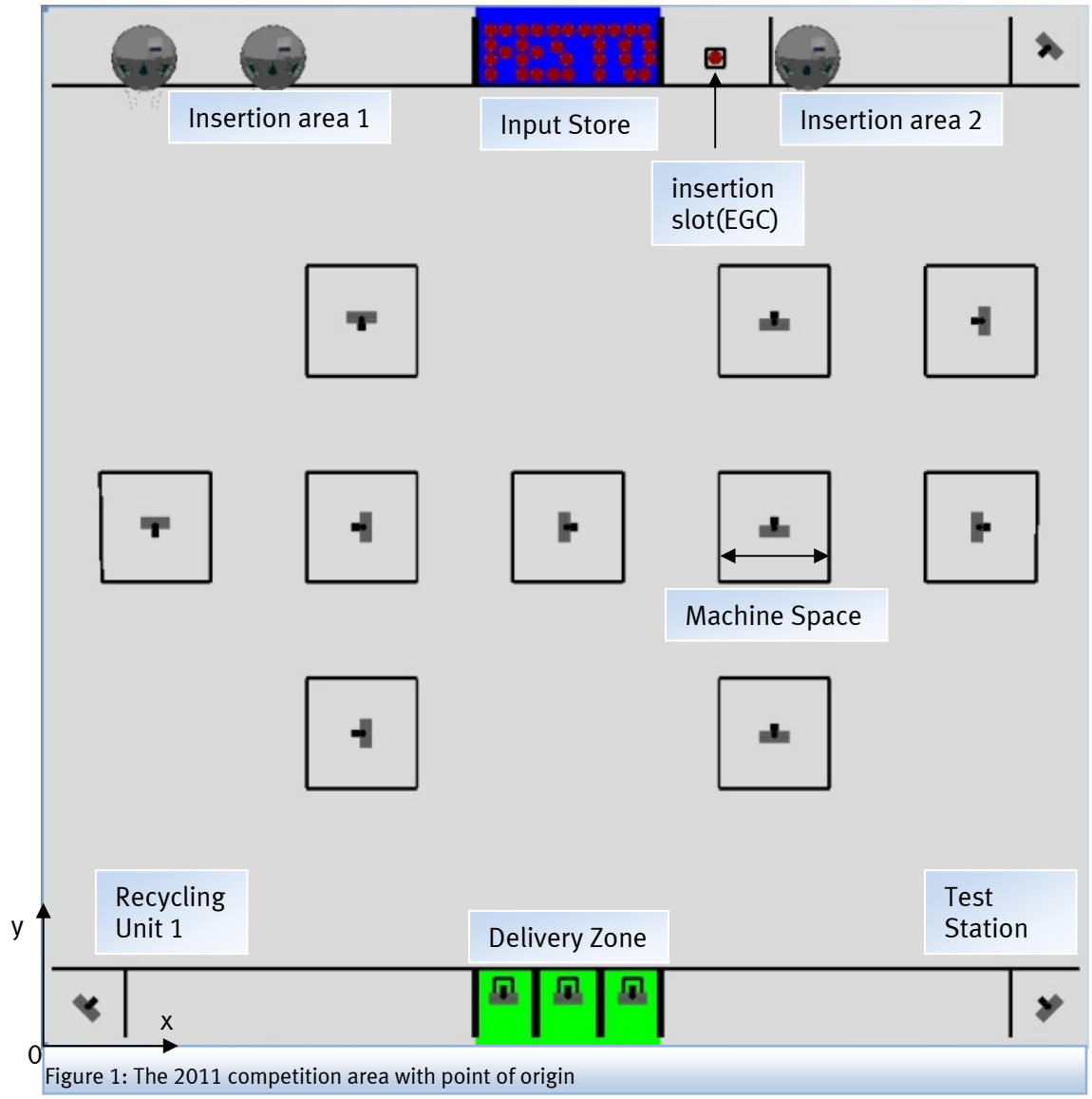

Figure 1: The 2011 competition area with point of origin

The bottom zone is marked “green” and houses the three delivery gates. Each gate is of 0.3m width with 0.1m space to the next delivery gate separated by black mark-ups.

The delivery gates feature one signal per gate placed middle of each gate zone. The delivery slot resides below a unit that is identical in construction to a production machine. The three RFID devices within these gates feature a black centered square of 0.1 m x 0.1 m called delivery slot and residing exactly below the RFID device. Only a pallet carrier that is delivered into the slot completely will be considered for scoring, i.e. no part of the pallet carrier may surpass the boundary of the slot.

A total of 13 machines are placed within the competition area. 10 machines representing the 3 staged production processes, 2 machines to recycle consumed pallet carrier and 1 test station. The machines of the production process are placed within the factory area as stated in the table below. They are aligned in a 90° angle. Each production machine resides in the centre of a squared machine space spanned by standard mark-ups with 0.6 m each side.

The 3 additional machines are arranged in the corners of the competition area, and aligned 45°, facing the centre of the factory area. The top left corner will remain empty.

3.1 Coordinates of production machines:

Number	X [m]	Y [m]
Machine 1	1,68	1,68
Machine 2	3,92	1,68
Machine 3	0,56	2,80
Machine 4	1,68	2,80
Machine 5	2,80	2,80
Machine 6	3,92	2,80
Machine 7	5,04	2,80
Machine 8	1,68	3,92
Machine 9	3,92	3,92
Machine 10	5,04	3,92
Recycling unit 1	0,20	0,20
Recycling unit 2	5,40	5,40
Test station	5,40	0,20
Express good insertion point / slot	3,60	5,35
Delivery slot 1	3,15	0,26
Delivery slot 2	2,80	0,26
Delivery slot 3	2,45	0,26

3.2 The Pallet Carrier – Puck

Figure 2: The tournament puck

The data carrying RFID tag is mounted to a hockey puck.
The tournament puck features a diameter of 7.5cm.

Please contact us if the pucks supplied do not look like the one from the figure on the left (color).

3.3 Machines

3.3.1 General Information

Figure 3:
Processing machine

All machines are identical devices consisting of

- one plate housing the RFID read/write device and
- one signal unit according to the figure above.

They share the same design and the same RFID device, with the overall size of 280 mm height, 160 mm of width and 100 mm of depth, see the engineering reference for further details.
The default operating mode of all machines implies that only the green LED is turned on. This signals the machine being ready for input. The reading and writing process generally is a delicate process. To avoid corruption of the data carrier, it should not leave the working range of the RFID device once the processing or consuming is started.
To enable the production process it is necessary to transport the pallet carrier accurately to the RFID device. A consumed pallet carrier has to stay within the machine space until the production cycle of that very machine has been completed. Production resulting from violating this requirement is considered junk and will not be rewarded. The machine always processes the required pallet carrier delivered last, all prior components will be consumed.
All machines will start processing the data carrier as soon as they enter the diameter named below and change their operating mode according to the tables provided.

3.3.2 Production Machines

Optical Feedback	Operating mode
All LEDs turned off	The machine is physically offline, caused by a real error which should not happen during the competition.
Red LED turned on	The machine is **out of order**
Green LED turned on	The machine is **idle and ready.**
Green and yellow LED turned on	The machine is **processing or consuming** the current data carrier.
Yellow LED flashing(at 2 Hz)	The machine detects **wrong material**. This can be caused by data carriers that are already consumed, subassemblies that do not fit to this machine type's work order or corrupted data carriers.
After processing the current data carrier:	
Yellow LED turned on	The machine has finished processing the current data carrier and is **waiting for the next subassembly**.
Green LED turned on	The machine has **finished the work order** and is ready to receive the next batch of carriers.

In order to complete the machines' work order the input materials have to be delivered one-by-one into the RFID device's action range. Multiple data carriers in range of the device will result in erroneous behavior of the device.
Consumption of materials, like S0 used in the production of S2, will take 2 seconds. Unloading the machine can be done immediately after the operating mode changes away from processing. As long as the machines are used properly, they will not produce any junk.

Machine Type	Input	Output	(Final)processing time[s]
M1 (5 times)	S0 (Raw-material)	S1	WT1 = 3 to 8
M2 (3 times)	S0; S1	S2; one consumed container	WT2 = 15 to 25s
M3 (2 times)	S0;S1;S2	Product; two consumed containers	WT3 = 20 to 40s

3.3.3 Recycling Unit (former market place)

The recycling unit processes all supplied loading carriers back to raw-material (S0) within 2 seconds.

Optical Feedback	Operating mode
All LEDs turned off	The machine is physically offline, caused by a real error which should not happen during the competition.
Red LED turned on	The machine is **out of order**
Green LED turned on	The machine is **idle and ready.**
Green and yellow LED turned on	The machine is **processing** the current data carrier.

3.3.4 Reading device

The reading and visualizing the data carriers content happens almost instantly after delivering the pallet carrier to the action range of the device.

Optical Feedback	Stored data on the data carrier
Green LED turned on	The station is ready to read the next data carrier.
All LEDs turned off	Consumed pallet carrier.
Yellow LED turned on	Raw-material (S0)
Red and yellow LEDs turned on	Subassembly 1 (S1)
Red LED turned on	Subassembly 2 (S2)
All LEDs turned on	The final product (P)

3.4 Delivery Gates

Optical Feedback	Stored data on the data carrier
Red LED turned on	This delivery gate is inactive.
Red and green LED turned on	This gate is active, namely the designated gate.

As soon as a pallet carrier is successfully delivered to the active gate, it will show the state of the data carrier as described above. This state will only long for some seconds and only for scoring reasons. There will be only one active gate at a time.

4 The Robotino® System

All participants have to design their competition Robotinos® within the following specifications:

- Any kind of sensors can be changed or added to the Robotino® platform. However, it is not possible to implement sensors that require modifications outside the Robotino® area (e.g. Northstar, indoor GPS).
- It is furthermore strictly forbidden to implement any kind of RFID device into the Robotino®.
- There must be no changes to the controller or mechanical system.
- The pushing device is defined as a passive, non mechanical load handling attachment.
- The robots peripherals must neither exceed the maximum total height of 0.7 m nor the 0.4 m diameter of the body cylinder. The only exception to this is the one default mounted pushing device per robot. The pushing device can be modified; it however must not exceed the following outside dimensions: 0.195 m x 0.135 m x 0.035 m.

For a detailed technical description, refer to the Engineering Specifications chapter 1.1

4.1 Communication

Each robot has to operate autonomously. The communication between the robot and the device responsible for the Start/Stop command, as well as all communication amongst the robots has to be realized using the Wi-Fi connection.
The program controlling the robot has to be executed locally by the robot itself. It is strictly forbidden to use any kind of external server acting as command point. The robots are allowed to share information with other devices, but must receive nothing else but the “start”, “pause” and “stop” command from units other than the 2 fellow robots.
This specifically excludes:

- Usage of processed image data created outside of the robots
- A central communication that requires a device other than the three Robotinos®
- A permanently established connection between the command device and the Robotinos®

Please refer to 5.3.2 for further details.

5 Tournament

5.1 Setup

A match is defined by two contesting teams competing at two separated identical competition areas. Each match lasts 15 minutes with 5 minutes of setup time unless stated otherwise by the organization team. All settings, even random events, will be the exact same for both parties of a match.

5.2 Team setup

No team member is allowed to enter the competition area prior to or during a match. The robots can be set up within the robot insertion area as long as they are outside the factory area and have not been elevated into their autonomous state. During a match the manipulation is limited to adjustments on sensors, checking cable connections and the boot or shut down procedure.
A team can ask the referee to shut down the robot. The referee will then move it to a point of insertion of the team's choice, once. The robot will be removed from the competition area on the second occasion. Resetting or removing a robot will not cause an interruption of the game. The referee will only interrupt the game if there is no other way to reset the robot without interfering with the other ongoing processes.
Once removed from the competition area the robot cannot be reinserted during the same match. A team can also decide to remove their robot from the competition area at any time of the match.

5.3 Setup environment

5.3.1 Machine Initialization

The physical distribution of the production machines is fixed. Their alignment will be randomized during the event setup but will stay that way through the whole event. The machine type of each production machine will be randomized prior to each match. The processing time of each machine type will be determined in the same way, so the waiting time during a match will be static for each machine of the three machine types (e.g. all M1 could have 7 seconds processing time).
The active delivery gate will also be randomized prior to each match but during a match the active gate can switch.

5.3.2 Radio Interference

The referee will induce a connection breakdown between the command unit and the Robotinos® at certain points of a match. This will not affect the Wi-Fi connection between the Robotinos® and will neither happen during the first minute of a match. Once switched off, the link between LAN and Wi-Fi will stay severed for 100 seconds. The link will be reactivated swiftly in case of emergency to interrupt the autonomy of the process.

5.4 Match startup

All matches will start at the exact time scheduled by the organization team. From this point on, the teams involved are allowed to start their robots to work autonomously. This can be done by one click per robot on any kind of interface.

5.5 During a match

The referee can interrupt the match at any time. Then, both teams have 5 seconds to stop all robot movement. The match time will be paused during the interruption. A team can decide to stop the autonomy process of each robot individually at any time of the match. Doing so has to be announced notably in order to inform the referee, as this is considered a shut down request according to 5.2.
Robots that do not stop within the time limit will be treated in the same way.

5.5.1 Out-of-order

The downtime generator will take down a maximum of two machines out of the pool containing production machines and recycling units. It will do so at random points of time. There will be 6 to 8 of such triggered events during a match.
The machines affected will remain out of order for 60 to 120 seconds. Every machine can only be forced out of order once per match. If the machine turns offline during processing or consumption of mounted a pallet carrier, it will afterwards resume the process.

5.5.2 Express good challenge

The challenge will be induced by the referee seeding one loading equipment into the express goods slot. The challenge then has to be completed within 120 seconds. The loading equipment has to be processed at a machine of type 1 with the corresponding WT1 as processing time. Prior to handling the express good, the designated machine has to be put into an identified state. This is done by a raw material that was processed in this very machine earlier during the on-going match. The identification process does not have an effect on the further usage of the produced subassembly 1, it can be used naturally.
After processing the express good has to be delivered to the active delivery gate.

5.6 Mode

5.6.1 Tournament specifications

The tournament features two stages with the first stage being done in league form with several sequels orientating at the number of participants and a second stage with playoffs featuring the top 4 teams.

Each match will be resulted with the score of each team. The winning team will be awarded 2 major points. In case of a draw both teams will be awarded with 1 major point. In case both teams scored zero points, no major points will be awarded.

In case of a draw within the playoffs, the game time will be extended by 5 minutes unless both teams scored zero points.

If this extension leads to a draw too the overall regular points of the teams will determine the match winner. If the overall points are equal too, the teams will approach a coin toss to determine the winner.

The detailed seeding will be created at the event. Although the idea is to allow each participant to challenge each other team the league can be adjusted to meet time requirements.

5.6.2 Tournament challenge

Phase	Remark
League phase	- -The active delivery gate will not switch during a match. - -There will be 3 express good challenges.
Playoffs	- The active delivery gate will swap twice after 7 and 11 minutes. A delivery made to the old active gate will be still valid for the next 10 seconds. - -There will be 4 express good challenges.

In both cases, delivered pallet carriers will be removed from the game by the administration and therefore cannot be recycled.

5.6.3 Wi-Fi regulations

In order to provide the optimal possible solution for wireless communication during the event, all teams are required to use the 5 GHz Wi-Fi equipment. They are furthermore required to connect their Robotinos® Wi-Fi unit to the access point provided. All teams can also relay on Wi-Fi clients supplied by Festo but are not required to. A detailed description concerning the infrastructure can be found in chapter 1.8 of the Engineering Specifications.

5.6.4 Task fulfillment

The following table provides the itemized clearance of all task related processes.

Subtask	Description	Scoring [Point]
Produce S1	Process raw-material into subassembly 1	+1
Produce S2	Consume raw-material and process S1 into S2	+4
Produce P	Consume raw-material and S1 to process S2 into the final product	+10
Deliver	Deliver the final product to the designated loading zone	+4
Recycle	Deliver the 3 consumed loading carriers to a recycling unit (independent from a correct delivery of the product)	+6
Sum	Total points a team will receive for a produced and correctly delivered final product with its consumed loading carrier recycled.	**25**
Mount Express Good	Accept the express good challenge in time, namely completely removing the puck from the slot.	+2
Finish the EG	Deliver the EG to a machine of type 1 and process the express good in time if the machine type was identified by an earlier production process.	+3
Deliver the EG	Deliver the processed express good to the active delivery gate in time.	+10
Sum		**15**

~~**5.6.5 Compensation for partial fulfilment**~~

~~In 2011 partial or erroneous fulfillment will be slightly rewarded.~~

~~Subtask~~	~~Description~~	~~Scoring [Point]~~
~~**Deliver Subassemblies**~~	~~Deliver a subassembly to the designated loading zone.~~	~~+2~~
~~**Attempt of delivery**~~	~~Deliver a subassembly or the final product to the wrong loading zone.~~	~~+1~~
~~**Recycle**~~	~~Recycle a consumed loading carrier that did not support production of a final product.~~	~~+1~~

~~Canceled.~~

5.7 Penalties

This catalogue represents the decision basis of the referee without being exhaustive or binding.

Issue	Sanction
Match related	
(1) Premature movement	
No robot is allowed to move until the referee announced the start of the match	The faulty robot will be grounded for 2 minutes
(2) Damaging factory equipment	
Theoretical damage to the "real" factory equipment as a result of collisions and negligent actions.	The team will be punished with a score reduction. The total score cannot drop below zero.
Housekeeping	
(3) Team showing up late to a match	
This includes showing up late to a match.	The according match will receive a score reduction. The total score cannot drop below zero.
(4) Not showing up	
A team not showing up at all.	The team will be removed from the tournament unless the team leader can provide a sincere explanation
(5) Breaking a minor rule	
A rule infringement with none or little impact on the team performance	The team will receive a warning or a small score reduction
(6) Breaking a major rule	
A rule infringement with considerable impact on the team performance or competition mechanics.	The referee will decide upon calling a team vote or imposing an adequate punishment.
(7) Arguing with the referee	
There will be no discussions during a match. Each team can make a motion to protest a certain match and its result which will be dealt with after the match.	There will be a warning. Continued disregard will result in a time punishment to the team's current or next match.
(8) Disregarding rules of conduct	
Following the rules of conduct should be self-explanatory	Upon disregard, the referee will impose sanctions ranged from time punishments to the team's complete removal from the tournament.

6 Development / Vision

This section is meant to enable discussions and support investment decisions for future soft- and hardware acquisitions.

6.1 Short term ideas

These are ideas that could still be incorporated into the rulebook of Istanbul 2011.

6.1.1 Scripted, dynamic obstacles

On the way to fully dynamic obstacles this iteration implies a fully scripted administration controlled Robotino® that follows implicit movement rules that are known to all participants.

6.2 Midterm planning

Additions and alterations for future iterations of this competition

6.2.1 Various Production programs

A part from the three-staged production process, various goods with different work orders and specifications (e.g. top speed, delivery strategies...) could be part of the challenge.
This addition seems to be heavily dependent on 6.2.4

6.2.2 Various order strategies

A delivery could consist of more than one final product, it could be required to deliver a batch of products, maybe within a certain time span, to complete the loading and receive extra points. Also, the different delivery gates could obtain a predefined shipping list, for example gate 1 requiring 2 Products, 2 M2 and 1 M1, maybe in the correct order to enable FIFO, LIFO or other delivery strategies.

6.2.3 Simulation league

Since there is only the annually world championship and maybe a regional preregistration, a simulation platform could be provided, where the software framework of teams can be used to compete with other teams. Additionally a branch of simulation could be created that focuses on the simulation of many AGV and a huge production area in order to compete on scalability.

6.2.4 Introducing a supportive flow of information

As the current task only deals with the material stream, it is heavily limited to a simple static task. In order to enable a flow of information that transports complex orders, a combined effort should focus on implementing a data interface that can be used by all teams today and in the future. As this would be a giant leap towards the industrial application, a general discussion and a lot of effort has to be invested into this issue.

6.3 Long term Vision

Ideas, dreams and ideology that inspire the future development.

6.3.1 Complex production machines

As there are more ways to interact with a machine than mounting and dismounting a loading carrier, it is possible to develop new machine types that look different and are completely different to handle.

6.3.2 Collaborative Production

Teams could be required to cooperate with another team to enable a combined supply chain.

6.3.3 Opponent controlled dynamic obstacles

No scripted obstacle can truly represent challenges of the industrial application. In the long run, an opposing team has to be reinserted that is allowed and requested to anticipate the logistic processes in real time in order to create worst case scenarios for the teams.

6.3.4 Interfacing ERP / SCM

The interface used to present orders could be back ended with software from real business applications like ERP, PPS, WHM and SCM.

6.3.5 JIS / JIT implementation

With complex production processes and several other achievements and upgrades it could be useful to implement JIS and JIT tasks and procedures into the FLC, requiring delivery strategies like LIFO, FIFO and certain time windows.