High Octane

BEST 2009 Design Contest

Game Specific RULES

Version 2.02

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Boosting Engineering, Science & Technology™

BEST Game Specific Rules
ACMR00005 Revision 2.02; August 2009

1.0 Introduction

Recent fluctuations in oil prices have captured the attention of political leaders, investors, and fuel-researchers alike. It has been common knowledge that our dependence on foreign oil is a long term liability to our economy. Though many have lobbied for investments in alternative fuels, research and development of high-density energy sources has yielded only limited success. Thus far, no other energy source has been able to dislodge fossil fuels as "king of the hill." Collectively, our cost/benefit analysis for moving to alternative fuels has left us indulging in the comforts that fossil fuels allow. However, the relative costs are about to change.

Scientists in the BEST Robotics think tank have recently made breakthroughs leading to a new renewable resource. We have discovered a superchlorophyll catalyst that, theoretically, will facilitate the production of long hydro-carbon chain molecules from plentiful CO_2 and H_2O…at least we think it will. In short, we aim to make combustible fuels from common resources and a catalyst derived from plant tissue.

Before going public with the discovery we need to prove the concept and demonstrate that the reactions can be performed efficiently in an automated environment. This will be a very expensive exploration and we are under dire time constraints (the world awaits!).

Fortunately, investors have contributed funding to conduct this exploration. Unfortunately, the funding is rather limited and the test environment has to be scaled down…way down. Resource quantities, production facilities, and chemical inventories must all be carefully controlled in this exploration phase in order to precisely predict cost and efficacy of production on the national scale. Accordingly, the size, weight, and construction materials for all automated units, i.e., "robots," will be restricted (see the BEST Generic Game Rules GMRK00001) during the tests. If the process can be completed under these tight constraints described in this document, then we'll know that it can be accomplished in industry.

The BEST Octane Research Team is issuing the following call for assistance. **Teams of pre-collegiate students are invited to contrive strategies and associated robots to maximize production of isooctane in a resource restricted environment.** The strategies and automated units will be demonstrated concurrently with other teams' designs within strict time limits in order to prove that the processes can be conducted safely and efficiently even when raw reactants are limited. As in the real-world, no points will be awarded. Rather, the relative strength of each team's design will be measured by the accumulated inventory of reactants, intermediate products, and final product at the end of the competition event.

The competition event (i.e., game day) will consist of three stages: the seeding competition, the semi-finals, and the finals. After each stage, the teams with the most valuable inventory will continue to the next stage of testing.

2.0 Game Objective

During the demonstrations, the objective is for teams to collect and employ common molecules (CO_2, H_20) and essential resources (energy, catalysts) to complete a series of chemical reactions. The eventual goal is to produce isooctane, or alternatively, the lesser valued naphtha. Intermediate products (ethylene, benzene) that are generated in the process are retained in the team's inventory for later use.

During the seeding competition, teams will collect H_20, Catalysts, Energy, and CO_2 in an effort to synthesize ethylene molecules according to the reaction equation:

[Equation 1] $2\ CO_2 + 2\ H_20 + \text{Energy} + \text{Catalyst} \rightarrow C_2H_4\ (\text{ethylene}) + 3\ O_2$

In other words, it takes two CO_2 units, plus two H_20 units, plus one Energy unit, plus one Catalyst unit to produce a single unit of ethylene and oxygen (which is altogether ignored in these demonstrations).

Advancing teams will use their previously accumulated ethylene (a maximum inventory of three units can be carried over from the seeding rounds) and ethylene that they can synthesize during their matches to synthesize as much benzene as possible according to the reaction equation:

[Equation 2] $3\ C_2H_4 + \text{Energy} + \text{Catalyst} \rightarrow C_6H_6\ (\text{benzene}) + 3\ H_2$

As with the O_2 in Equation 1, the H_2 product is waste gas and is not added to inventory. Teams can then choose to apply Benzene to two final objectives. They can either synthesize naphtha by:

[Equation 3] $C_6H_6 + 4\ H_2 + \text{Energy} + \text{Catalyst} \rightarrow C_6H_{14}\ (\text{naphtha})$

Or they can employ additional ethylene to make the more valuable isooctane according to the reaction:

[Equation 4] $C_6H_6 + C_2H_4 + 4H_2 + \text{Energy} + \text{Catalyst} \rightarrow C_8H_{18}\ (\text{isooctane})$

Teams are **not** restricted to any one of the above reactions during any stage of the competition event. They are free to pursue any of the reactions that their inventory and available reactants/resources might allow them to complete. For example, it is theoretically possible during seeding for teams to produce sufficient quantity of ethylene such that benzene can be generated.

In these scaled-down demonstrations, the inventory that can be carried from one match to the next is strictly limited. No more than three units of each reactant/resource can be carried forward. Fortunately, excess reactant/resource will **automatically** be traded for the next higher value reactant/resource on the "open market." The automatic trades cannot be overridden. The relative value of each reactant/resource is as follows. Four units of H_20 will be automatically traded for one unit of catalyst. Four units of catalyst will be automatically traded for one unit of energy. Four units of energy will be automatically

traded for one unit of CO_2. Four units of CO_2 will be automatically traded for one unit of ethylene. Four units of ethylene will be automatically traded for one unit of benzene. Four units of benzene will be automatically traded for one unit of naphtha. Four units of naphtha will be automatically traded for one unit of isooctane.

During the demonstrations, each team will be equipped with an automated virtual lab that will automatically utilize any available inventory to complete the previously described equations **whenever possible**. This automated process cannot be overridden and will be performed at the end of each match using newly acquired commodities as well as any previously existing inventory.

It is worth restating that the H_2 waste gas (in Equation 2) is NOT added to inventory when benzene is created. It is also important to note that the H_20 units can be used for either H_2 or H_20 as needed in Equation 1 through Equation 4.

3.0 Game Field Description

The game field is approximately 23 feet by 23 feet, and is laid out as depicted in Figure 1. As shown, the field is divided into four symmetric quadrants. Robots may move about in each quadrant but have clear advantages, as described later, in the “home” quadrant where they begin the match. The Processing Plant is located in the corner of the quadrant and houses all the receptacles where game pieces must be placed to be added to the team’s inventory at the end of the match. Human team members (plant Operator and Field Specialist) have designated areas on the perimeter of the field where they can participate in the team’s activities. The plant Operator generally plays the role of the “spotter” in previous games. The Field Specialist generally plays the role of the “driver” in previous games.

The virtual boundary for an area that is indicated by tape shall be the far side of the tape with a vertical boundary extending up to infinity. For example, the tape “line” indicating the robot’s home quadrant establishes a virtual boundary between the home quadrant and the neutral area. The edge of the tape farthest from the home Processing Plant is the vertical boundary for the home quadrant. The neutral area is defined as all the space between the various home quadrants. Similarly, the robot starting area is indicated by the outside boundary of the tape.

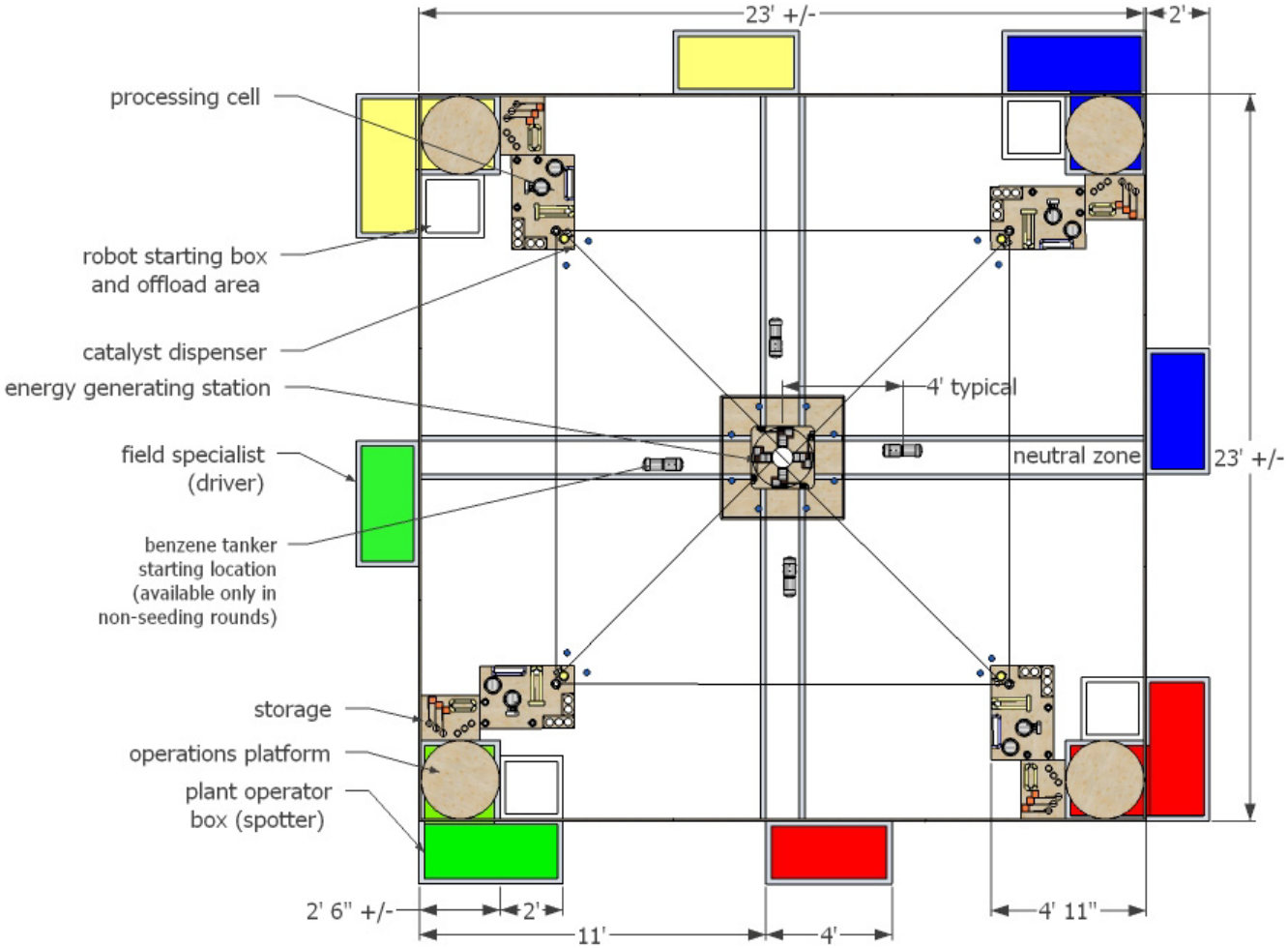

Figure 1. Plan view showing location of primary field components. CO_2 has been omitted for clarity.

3.1. Energy Generating Station (One on field)

The Energy Generating Station (EGS) is located in the center of the field as shown in Figure 1. An isometric close up of the EGS is shown below. The EGS platform deck consists of two levels. The upper level supports the EGS carousel and energy dispensers. Spacer blocks create an area between the two levels which houses EGS control wiring and the BRAIN which controls the automated laboratories. Both levels of the platform deck are strictly off limits to robots. Robots are only allowed to interact with the EGS below the platform deck (below the top surface of the lower deck). Robots may interact with the side and bottom surfaces of the lower deck as long as no other rule is violated while doing so.

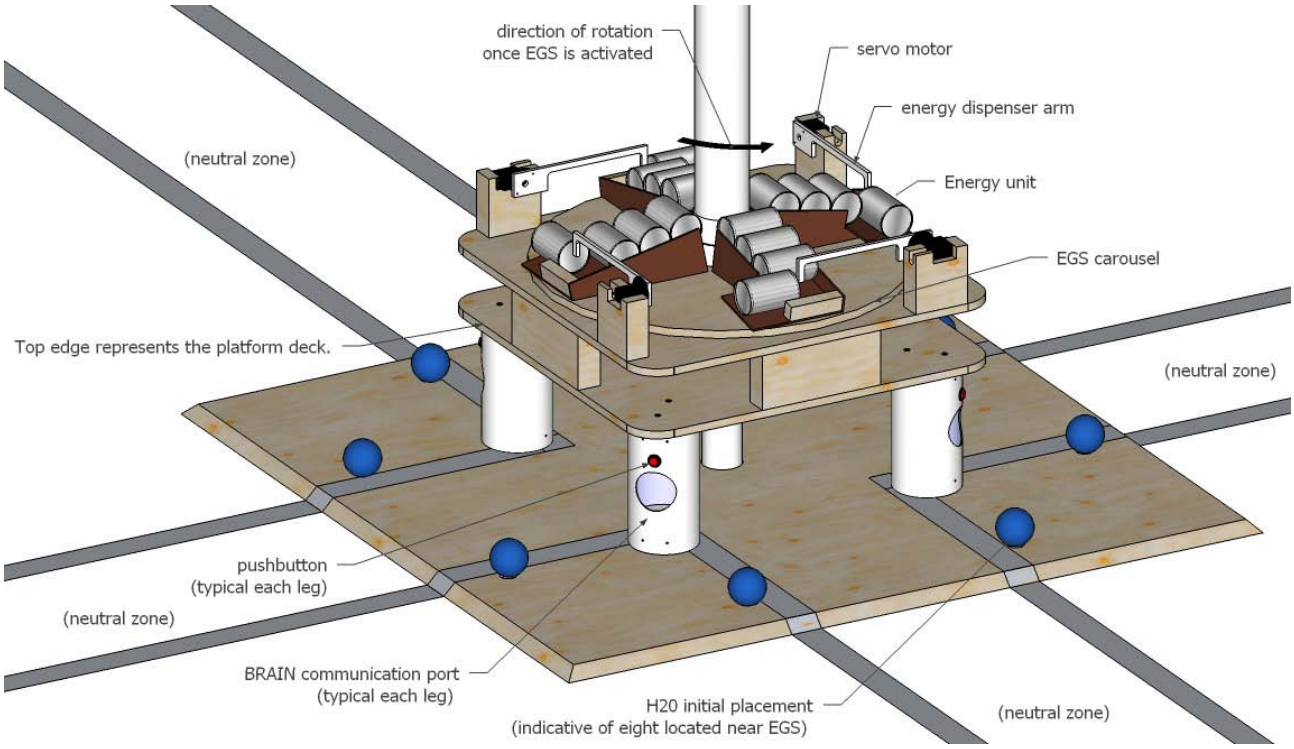

Figure 2. Energy Generating Station components and initial H_2O location.

The platform deck is supported by four legs, located near its corners. Each leg houses a mechanical pushbutton and a BRAIN (IR) communication detector. Either of which can be used to activate the EGS dispensers. However, each affects the EGS operation differently as described later.

The platform deck supports a carousel on which four energy dispenser chutes are installed. When the EGS is activated, the carousel will begin rotating (at approximately one revolution per minute) to facilitate the dispensing of energy units. The EGS carousel can be activated by the EGS mechanical pushbuttons, the BRAIN IR communication port, or the pushbuttons located on the Catalyst dispensers. Once activated, the carousel will continue rotating for the duration of the match. However, each Energy dispenser mechanism continues to operate independently as described later. The platform deck is approximately 24” square with rounded corners. The carousel is approximately 23” in diameter. The legs are approximately 8” tall.

There are four Energy dispenser chutes spaced equally around the carousel. Each chute begins the match with four Energy units installed. There are four diverter mechanisms installed on the platform deck. When a diverter mechanism is activated, it will divert one Energy unit from a chute as it passes the diverter arm. The diverted Energy unit is expected to fall towards the respective neutral zone if left untouched. The mechanical pushbutton affects only the diverter mechanism to the right of the pushbutton (i.e., the next dispenser mechanism counterclockwise from the button when viewed from above). Activation via BRAIN IR communication port can affect either the diverter to the left or right or both.

There is a tower in the center of the EGS that uses proprietary technology to interact with the stratosphere causing the CO_2 there to stream predictably. In this scaled down demonstration, the tower supports lightweight filament lines on which CO_2 units are installed.

H_20 has been observed to pool near the legs of the EGS. During the demonstrations, two H_20 units will be located near each of the EGS legs resting in small holes cut in the EGS base.

3.2. Catalyst Dispenser (Four on field)

The Catalyst dispenser is a PVC tower located near the corner of the processing cell located in each corner of the field; see Figure 1 and Figure 3. Each dispenser begins the match with four Catalyst units installed. The Catalyst units are dispensed by a BRAIN driven motor when the Catalyst dispenser is activated. The dispenser may be activated by a mechanical pushbutton located on the dispenser or by the BRAIN IR communication port (located on the Energy Generating Station). The rate at which the units are dispensed is generally dependent on the tiebreaker activation order. When released, a Catalyst unit is expected to have sufficient momentum to traverse the field to the neighboring processing plant. However, the unit's exit path and velocity should be considered chaotic with only a statistical bias towards the neighboring processing plant.

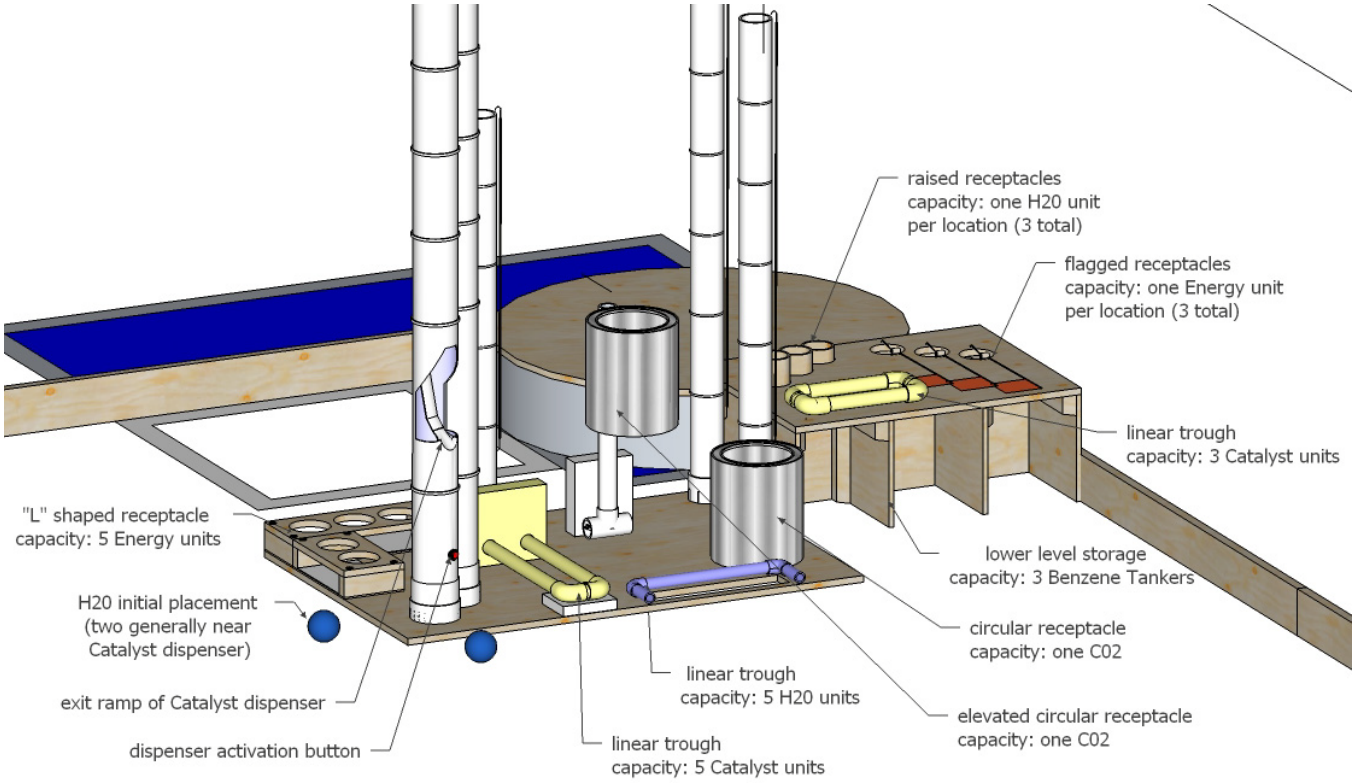

Figure 3. Receptacles in the processing cell and storage area for items collected during a match.

3.3. Processing plant (four on perimeter of field)

The processing plant is home to four distinct areas: operations platform, storage, offload area, and processing cell (each of these areas is indicated in Figure 1). Only game pieces that are located in appropriate receptacles within the processing plant at the end of the match are eligible to be added to the team's inventory.

3.3.1. Operations Platform and Operator Area

The operations platform is a cylindrical platform (6" tall and 30" diameter) upon which the Operator (i.e., spotter) may stand or kneel to perform actions according to the team's strategy. The operations platform is strategically located to facilitate the movement of game pieces about all the Operator-accessible areas (operations platform, Operator area, offload area, and upper level of the storage area). The formal "spotter area" (as the position was referred to in past games), or Operator area, is a 2'x5' area outside the field boundary. However, there is no distinction between allowable Operator activities within the Operator area and upon the operations platform. Practically speaking, the operations platform is installed in a 30" square extension of the Operator area. The home robot is allowed to place pieces directly into the Operator area and/or operations platform area as long as no other rule is violated in doing so. Items in the operations platform area and within the Operator area may be handled and manipulated by the Operator as long as no other rule is violated in doing so.

3.3.2. Storage

Storage consists of two levels. The upper storage area has receptacles for H_20, Catalyst, and Energy. Storage is limited to three of each of these commodities. The upper storage area may be accessed by the Operator and/or the home robot.

The lower level of the storage area consists of three bays for receiving Benzene Tankers. Robots may attempt to place items directly into both levels of the storage area if desired. However, the lower level is off limits for the Operator.

3.3.3. Offload Area

This area shares the same physical space as the robot starting area. Items deposited into the offload area can be handled and relocated by the Operator as long as no other rule is violated in doing so.

3.3.4. Processing cell

In addition to serving as a mount for the Catalyst dispenser and stratosphere support leg, the processing cell houses designated receptacles for commodities (H_20, Catalyst, Energy, and CO_2) which have been collected and are intended to be added to the team inventory. Commodities (game pieces) are generally placed into the processing cell receptacles by the robots. The Operator may not cross the boundary to the processing cell.

As with all parts of the field, it is each team's responsibility to interact with elements within the processing cell in such a way as to not cause any damage. The intricate

nature of this part of the game floor will require special attention by the robot designers and the Field Specialists.

4.0 Game Pieces

There are five different **types** of game pieces, each with different starting locations and assigned receptacles in the team's processing plant. Some game pieces are located in the vicinity of the Energy Generating Station (in the center of the field), some are waiting in dispensers (that must be activated to release the game pieces), and some are elevated above the floor. The availability of game pieces varies between the various stages of the competition event.

4.1. Description of Game Pieces

H_2O: During the demonstrations, water will be represented by standard racquet balls. Each racquet ball represents one unit of H_20.

Catalyst: During the demonstrations, catalyst will be represented by standard yellow tennis balls. Each tennis balls represents one unit of Catalyst.

Energy: During the demonstrations, energy will be represented by 6oz tomato paste cans (nominally 2-1/8" diameter and 3-1/4" tall). The cans are full and unopened and may or may not have a paper label on them. Each can represents one unit of Energy.

CO_2: During the demonstrations, carbon dioxide will be represented by beach balls (nominally 8.5" diameter when fully inflated). The balls will be reasonably inflated. No specification will be made concerning the final inflated pressure or the roundness of the ball. Robots should be prepared to cope with uncertain conditions including under-inflated, oblong, +/- 1" diameter, surface roughness, seam height, and air valve extrusion. Each beach ball represents one unit of CO_2.

Benzene: During the demonstrations, benzene will be represented by the Benzene Tanker truck assembly shown in Figure 4. Each tanker represents one unit of Benzene. The Benzene Tanker assembly is constructed using 4" pipe and wooden wheels as per the field drawings**.** The tankers carry a load that may shift when accelerated. The weight of the benzene in the tanker is approximately 16oz. Robots should be prepared to cope with the uncertain weight distribution within a tanker. As the tankers have been abandoned on the field for unknown reasons, teams should make only conservative assumptions concerning how well (if at all) the wheels roll on the field surface. Since benzene is highly toxic, operators are not allowed to touch or manipulate the tankers and there is a special inventory concern that will be discussed later in this text.

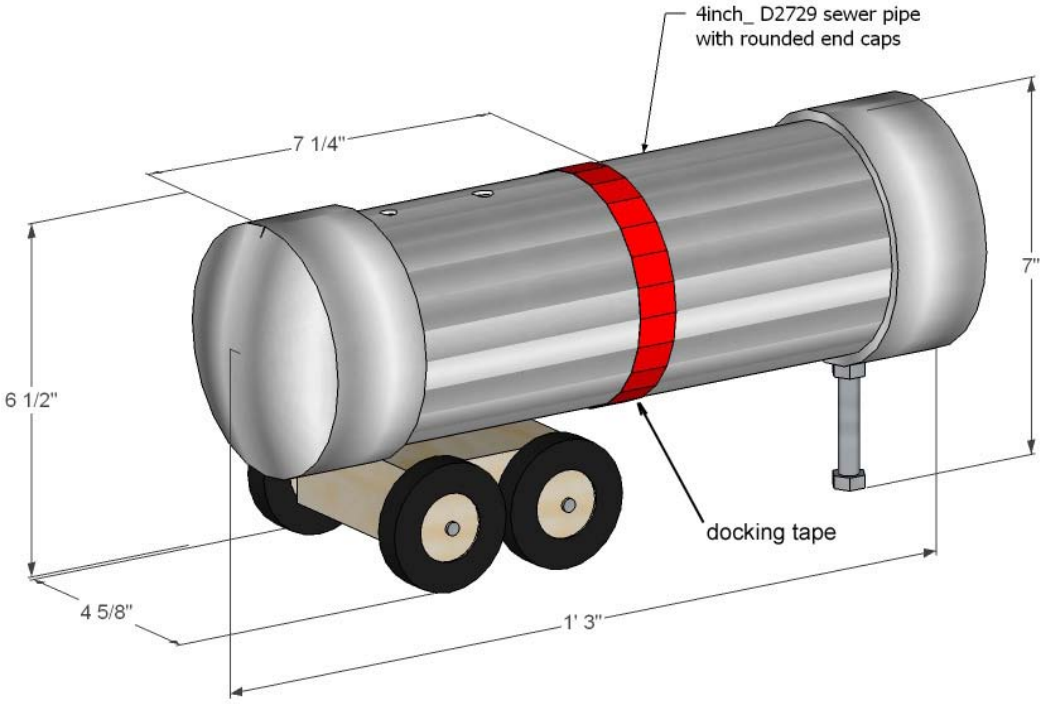

Figure 4. Overall dimensions of Benzene Tanker

4.2. Availability and Starting Location of Commodities during the Seeding Competition

At the beginning of each seeding match there are 16 H_20 units, 16 Catalyst units, 16 Energy units, and eight CO_2 units on the field.

Two H_20 units begin near the foot of each Catalyst dispenser within 12 inches of the corner of the processing cell (expected as shown in Figure 3). Two H_2O units begin near each of the EGS legs (expected as shown in Figure 2).

At the beginning of each match, four Catalyst units have been loaded into each of the four Catalyst dispensers. The position and approximate orientation of the Catalyst dispenser, relative to the processing cell is shown in Figure 3. When activated, the dispenser will begin releasing Catalyst at a steady rate based on the established tiebreaker order. The dispensing rate for the team holding the 1st tiebreaker position is approximately one unit per second. The rate for the 2nd team is approximately one every two seconds. The rate for the 3rd team is approximately one every four seconds. And the rate for the 4th team is approximately one every eight seconds. (The method for determining the tiebreaker position is described later)

Energy units are dispensed from the Energy Generating Station (EGS) located at the center of the field. Each of the four EGS Energy dispenser chutes begin with four Energy units, for a total of 16 Energy units located on the carousel. When a dispenser is activated using a mechanical pushbutton, the diverter will activate for a time period expected to release one Energy unit based on the normal rotational speed of the

carousel. There may be a delay between activation and actual dispensing due to the rotational position of the carousel relative to the diverter mechanism that was activated. If the dispenser is activated with the BRAIN IR communications port, the diverter will activate for the time period expected to release three Energy units. The dispensers can be reactivated during a match by either the pushbutton or BRAIN IR communication port.

There are eight CO_2 units available on the field at the beginning of each seeding match, two in each quadrant of the stratosphere. One begins at a height approximately equal to 48" from the floor to the top of the ball. The other begins at a height approximately equal to 30" from the floor to the top of the ball and its elevation gradually increases as it migrates along the stratosphere path. There are four symmetric filament lines that make up the stratosphere. Each line terminates with a weight suspended from the top of a stratosphere support leg. It runs to the top of an stratosphere support leg in the next processing cell, then partially down the length of the support leg, and finally to the top of the EGS tower. The diameter of the hub at the top of the tower is 4". When the EGS carousel is activated, the filaments making up the stratosphere will be wound onto the hub, causing the CO_2 units to migrate along the filament path. Slack will be pulled from the line by the weight hanging at its terminal end. Each CO_2 unit is suspended from the traveling filament by a short leader line. The leader line is connected to the CO_2 using a ¼" square patch of Velcro. The other end of the leader line is rigidly attached to the traveling filament. The 3-dimensional path of the CO_2 is described in Figure 5. Note that, the CO_2 units traveling parallel to the perimeter of the field begin approximately 5' from the nearest support leg and follow a path on which the elevation is generally constant (with the exception of incidental slack in the lines). However, the CO_2 units that begin near the processing cell (approximately 2' from the nearest support leg) will migrate towards the EGS while gradually increasing elevation. Over the course of a match, the filament may travel as much as 5' to 6' depending on when the EGS is initially activated, the exact turntable speed, and hub tolerances.

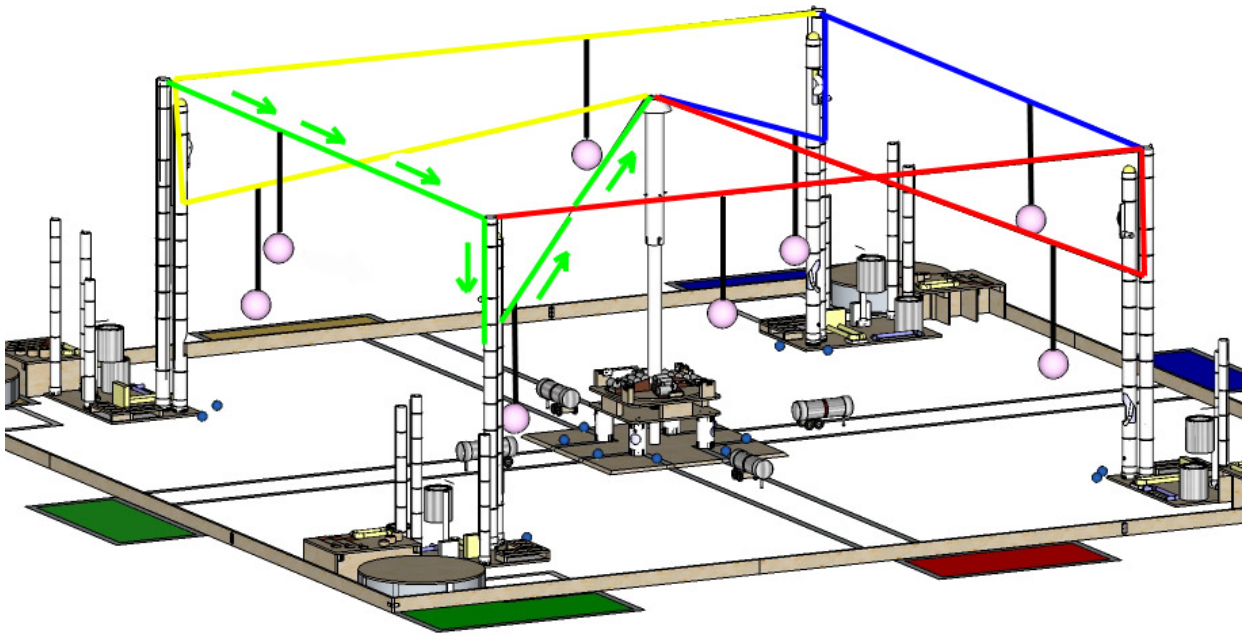

Figure 5. Isometric view of CO_2 path in each quadrant.

4.3. Availability and Starting Location of Commodities during the Semi-Final and Final Matches

Access to resources for making ethylene is made easier in the semi-final and final matches so that teams can demonstrate their efficiency at completing the more complex reactions.

There are still 16 H_20 units on the field, two near the foot of each Catalyst dispenser and two near each of the legs of the EGS.

Each Catalyst dispenser has four Catalyst units for a total of 16 Catalyst units on the field. However, now all four are released from the dispenser at a rate of one per second, regardless of the tiebreaker order. Further, 30 seconds after the first robot triggers a field sensor (either a pushbutton or a BRAIN IR communication port) all the Catalyst dispensers will automatically begin dispensing at a rate of one every eight seconds. This automatic dispensing of Catalyst marks the beginning of the “resource tsunami.”

Each Energy chute on the EGS will, again, begin with four units for a total of 16 Energy units on the field. However, now each dispensing request will enable the diverter for the approximate time required to dispense four Energy units. When the activation period expires, a robot may reactivate the dispenser. Additionally, all dispensers will be activated 60 seconds after the first robot triggers a field sensor (either a pushbutton or an BRAIN IR communication port) and will remain active for the duration of the match. The rapid dispensing of all the Energy completes the “resource tsunami” which began when the first Catalyst unit was released.

There are still two CO_2 units in each quadrant and their migration is the same as in the seeding rounds. Four Benzene Tankers are now distributed on the field as shown in Figure 1.

5.0 Inventory Tracking (Scoring)

No points will be awarded and no "score" will be kept. Rather, the relative progress of each team through the day will be indicated by the team's accumulated inventory of commodities (reactants, resources, and products).

Teams can accumulate inventory by either:

- collecting game pieces (catalyst units, energy units, H2O units, CO2 units, and Benzene Tankers) and placing said game pieces in an appropriate scoring receptacle by the end of the match; or by,
- accumulating sufficient inventory to complete reactions to produce ethylene, benzene, naphtha, and isooctane.

At the end of each match, any earned inventory is added to the team's inventory accumulated in previous rounds. Inventory levels will be tracked for each commodity and published as single digit columns listed in the following order:

Overflow	Units of isooctane	Units of Naphtha	Units of Benzene	Units of Ethylene	Units of CO_2	Units of Energy	Units of Catalyst	Units of H_20

In shorthand notation, the inventory will be represented as a 9-digit numeral (e.g., 020,123,001) with the rightmost digit representing the units of H_20 in inventory and digits towards the left representing the more valuable commodities (benzene, naphtha, and the most-valuable isooctane).

Market studies have shown that each commodity is valued at four times the next lesser-valued commodity and that they are trivially traded on the open market. In other words, four units of H_20 will be automatically traded for one unit of catalyst, four units of catalyst will be automatically traded for one unit of energy, four units of energy will be automatically traded for one unit of CO_2, etc. This automatic trade cannot be overridden. If the team does not want to "trade up" then they should refrain from accumulating more than three units of a commodity.

Teams should carefully consider the relative value of each commodity type when planning their strategy. Trading lesser-valued commodities for hard to obtain

commodities and leveraging the stoichiometry of Equation 1 through Equation 4 could allow a team to achieve a significantly higher valued inventory than focusing on only high-valued game pieces.

5.1. A Note about Game Strategy

In past robotic games, it was sufficient to plan a match strategy that might have some small adjustment in the various phases of the competition and some allowance for the other team's actions. Here, it will be important for teams to prioritize each match's activities in light of the already accumulated inventory and their bigger goals. For example, consider a team that has one benzene, three H_20, one energy, and one catalyst in inventory and they intend to make highly-valued isooctane (via Equation 4). If the Field Specialist mistakenly gathers one H_20 unit without also gathering/producing an ethylene, then the reaction for the lesser-valued naphtha will be exercised and the team will have to work to produce/gather more benzene to try again. Worse would be to gather three Catalyst units. In that case, the catalyst inventory would be converted to a unit of energy, depleting the catalyst from inventory, and making the Field Specialist in the next match do even more to complete the octane reaction. The prudent Field Specialist may have instead focused on CO_2 collection to complete an ethylene reaction and then accumulating four H_20 units to reach their end goal. Alternatively, a prudent Operator (who has access to the Storage "scoring" area) would simply discard an unwanted H_20 unit (or other game piece) if it keeps the team on track with their overall strategy.

Strategy must further consider where the match lies in the overall competition and what the team expects to achieve in their remaining matches.

5.2. Protocol for Calculating Accumulated Inventory

At the end of the match, the following steps will be performed, in order, to calculate the team's new accumulated inventory.

1. The commodities that are properly located in appropriate receptacles will be tallied with the commodities already in inventory accumulated in previous rounds.
2. If sufficient quantities exist for a stoichiometric balance of any of the reactions (Equation 1 through Equation 4), then the reaction producing the highest presently-possible product will be exercised first.
3. If sufficient quantities remain to satisfy other reactions, then the remaining reactions will be exercised beginning with the most valuable reaction first.
4. Once a commodity is reacted to produce a product, it is removed from the team's inventory.
5. If the remaining tally of any one commodity type is four, or more, then four units of that commodity will be traded for one unit of the next more valuable commodity.
6. Steps 3 through 5 are iterated until there is no further change in the inventory.

7. This is now the accumulated inventory that the team will begin the next round with.

5.3. Inventory Examples

Below is an example of the progress of two hypothetical teams through the first three rounds of competition. Their accomplishments are summarized in Table 1.

- In their first round, team A has collected one Catalyst and one H_20 unit. Team A's inventory is represented as 000, 000,011. Team B has collected one Catalyst unit and two H_20 units. Team B's inventory is represented as 000,000,012. At this time, team B's inventory is more valuable because 000,000,012 > 000,000,011.

- Team A manages to collect one CO_2, three energy units, and one H20 unit in their second round. When these commodities are added to their previously accumulated inventory, their new inventory is 000,001,312. In their second round, team B only collects two game pieces, but they are both CO_2 units. Added to their previously accumulated inventory give them a new accumulated inventory of 000,002,012. Even though A has collected more game pieces than B, B's inventory is still move valuable because 000,002,012 > 000,001,312.

- Up to this point, neither team A nor team B has collected sufficient resources to complete any of the reactions (Equations 1 through 4). Team A is lacking a CO_2 unit and team B is lacking an energy unit in order to complete the reaction for making ethylene (Equation 1). In the third round, both teams collect two Energy units. To figure out which team is ahead, we must carefully exercise the protocol for calculating accumulated inventory. Team B's is most evident. Now, that they have sufficient resources (two CO_2, two H_20, one Catalyst, and one Energy) such that Equation 1 is exercised converting these resources into one unit of ethylene. Team B's accumulated inventory becomes 000,010,100. Note, their surplus Energy unit is simply added to inventory to be used in later rounds. Meanwhile, team A didn't directly collect the required CO_2. However, they now have five Energy units, four of which are automatically traded up for one CO_2 unit. They now have sufficient reactants such that Equation 1 is automatically exercised to earn them an ethylene unit. Team A's new accumulated inventory is also 000,010,000.

In table form, the two team's achievement in their first three matches is as follows.

Table 1. Tracking inventory for two hypothetical teams.

round #	Team A		Team B	
	items added this round	resulting inventory after the round	items added this round	resulting inventory after the round
1	Cat, H_20	000,000,011	Cat, H_20, H_20	000,000,012
2	CO_2,E,E,E, H_20	000,001,312	CO_2, CO_2	000,002,012
3	E,E	000,010,000	E,E	000,010,100

If Team A had managed one more Energy unit, then they could have forced a tie. If necessary, the tiebreaker order would be used to rank teams having equivalent inventories. Note that commodities are carried forward in inventory and treated equally whether they are collected game pieces, commodities gained through automated trading (team A's second CO_2), or products produced by completing reactions (in this case, ethylene).

5.4. Game Pieces Eligible for Inventory

Game pieces are eligible to be added to inventory only if they are located in an appropriate receptacle at the end of the match. Each type of game piece has assigned receptacles shown in Figure 3 and further described here:

- As many as five H_2O units may be placed in the linear trough located in the floor of the processing cell. As many as one H_2O units may be placed in each of the three raised receptacles (vertical pipes) atop the Storage area. A H_2O unit is considered "in" a trough or receptacle if it is at least partly within the PVC boundary (extended upward to infinity) and if it, or a robot subassembly in which it is contained, rests solely upon the trough' perimeter or the raised receptacles and/or other eligible H_2O units and/or the floor directly beneath the trough.
- As many as five Catalyst units may be placed in the elevated linear trough in the processing cell. As many as three Catalyst units may be placed in the linear trough atop the Storage area. A Catalyst unit is considered "in" a trough if it is at least partly within the trough's PVC boundary (extended upward to infinity) and if it, or a robot subassembly in which it is contained, rests solely upon the trough's components (shown in drawing 2009PC-40 and 2009S-40: Detail B) and/or other eligible Catalyst units and/or the wood floor directly beneath the trough.
- As many as five Energy units may be placed in the "L" shaped receptacle located in the corner of the processing cell. As many as one Energy units may be placed in each of the three flagged receptacles (holes) atop the Storage area. An Energy unit is considered "in" a receptacle if it is at least partly penetrating a

receptacle hole and if it, or a robot subassembly in which it is contained, rests solely upon the receptacle and/or other eligible Energy units and/or the wood floor directly beneath the receptacle and/or the flag wire.

- As many as one CO_2 units may be placed in the lower circular receptacle and as many as one CO_2 units may be placed in elevated circular receptacle shown in Figure 3. A CO_2 unit is considered "in" a receptacle if it is at least partly within the receptacle boundary (extended upward to infinity) and if it, or a robot subassembly in which it is contained, rests solely upon the receptacle.
- As many as three Benzene Tankers may be placed in the lower level Storage bays. A Benzene Tanker is considered "in" the Storage bay if it is backed into the bay, wheels first, with its docking tape (a tape band around the tanker as shown in Figure 4) fully inserted into the storage facility and no part of the PVC cylindrical tank (including end caps) is in contact with the floor.

Additionally, no item that is in contact with the Operator or the "home" robot at the end of the match will count towards the team's inventory. However, if items are in contact with any robot subassembly that has become completely detached from the robot, then the items may still count towards the team's inventory if they are otherwise qualified to do so.

6.0 Operator Activity and Restrictions

It is the Operator's duty to relocate items from the offload area into the storage area as determined by the team strategy and to give guidance to the Field Specialist as appropriate.

1. The Operator's entire waistline must remain within the boundaries of the Operator area (approximately 2'x5' area outside the field perimeter) or atop the operations platform (small cylindrical platform on top of the plants primary storage tank) for the duration of the match. The Operator may relocate between these two areas during the match and may extend limbs outside of these areas as desired as long as no other rules are violated in doing so.
2. The Operator may handle and relocate any game piece or robot subassembly that lies entirely within Operator accessible areas (operations platform, Operator area, offload area, and upper level of the storage area) as long as no other rule is violated in doing so. If two subassemblies are connected by any means or are in contact with each other, then both subassemblies (and whatever is connecting them) must be entirely in the Operator accessible areas in order for either of them to be manipulated by the Operator. Any pieces suspected, by the referee, to have been moved illegally will be removed from the playing field by the referee. If any piece is not CLEARLY within the Operator accessible areas, then the Operator should wait until a referee declares the piece eligible before moving it. If the referee determines that the piece is arguably close to the Operator accessible areas but not actually in them, then the referee will clearly indicate so by relocating said piece (and all connecting pieces and subassemblies)

approximately 6 inches away from the boundary in question. The intent is to make the ineligibility of the piece clearly visible from a distance.

3. The Operator may not employ any artificial tools for communication or game piece manipulation.
4. The Operator may not touch or manipulate CO_2 units.
5. The Operator may not touch or manipulate a Benzene Tankers.
6. The Operator may not touch the lower storage area or any item that is at least partly within the lower storage area.
7. The Operator may not touch the field floor or the field boundary except within the Operator accessible areas (Operator area, operations platform, and offload area)
8. The Operator may not contact any game piece or subassembly that is also in contact with any robot. Any commodity or subassembly that is simultaneously contacted by an Operator and his/her team's robot, or is perceived by the referee to have been in simultaneous contact, will be removed from the playing field by the referee. Teams should avoid any actions that are not clearly in compliance with this rule.
9. If an item is accidently moved outside of the Operator accessible areas the robot must move it back into the area before the Operator can handle it.
10. An Operator may not use any item as a projectile (i.e. a body projected through the air and simultaneously experiencing significant horizontal and vertical components of velocity). Referees will remove such illegal projectiles from the playing field and will undo (as much as possible) any changes that the projectile caused to the field environment.
11. An Operator may not cross the boundary of a processing cell. Therefore they may not place or drop items into a processing cell. Theoretically, an Operator may roll items into any processing cell area (and any other part of any processing plant) as long as no other rule is violated in doing so. Any "rolled" item that traverses more than one horizontal foot before establishing rolling contact with floor will be considered a projectile.
12. An Operator may, intentionally or accidentally, return game pieces or subassemblies back to the playing field by dropping them or rolling them as long as no other rule is violated in doing so.
13. If an Operator's actions damage another robot, the Operator's team may be disqualified whether the damage was intentional or not.

7.0 BRAIN Advantage

BEST has unleashed the BRAIN and programmable control in this year's contest. In its first year of wide spread distribution, there was a wide variety of solutions implemented that would not have been practical using the legacy control system. These included: automated placement, channel expansion, and pre-programmed actions. BRAIN programming is now "unrestricted," limited only by the imagination of your software development team.

During the demonstrations (i.e., competition matches) there is opportunity for robots to interact with the field using the BRAIN and special IR sensors. While the game challenges can be accomplished without any custom BRAIN code, it might be advantageous for teams to leverage the robot/field interaction. Communications between the robot's BRAIN and the field's BRAIN is accomplished with an infrared (IR) transmitter provided in the kit. When connected to an available servo output, the robot will be able to instruct the field's BRAIN through IR communication ports located at the EGS. The robot can request actions from the field by sending messages to the field BRAIN from as far as several feet away. Specific codes have been defined to communicate requests to the field. The following are some of the advantages of communicating with the field BRAIN.

7.1. Universal Tiebreaker

Normally the Catalyst dispenser pushbutton will register the tiebreaker for a team (in addition to initiating catalyst dispensing). Alternatively, ANY command given via the IR field interaction method will register the team's tiebreaker. Thereby, teams are free to pursue strategies that don't involve the immediate gathering of Catalyst.

7.2. Accelerated Catalyst dispensing

Teams can instruct their Catalyst dispenser to release units at 1-second intervals regardless of their established tiebreaker order (which would normally dictate the dispensing rate).

7.3. Selectable Energy diverter activation

Normally, pressing any EGS pushbutton would activate the dispenser to the right of the pushbutton location. The IR protocol supports a dispense left, right, and both command. This allows selection of which dispenser to activate and can be useful if a competing a robot is already in place to catch an energy module that would be dispensed by using the mechanical method. Additionally, the instruction can include a extended activation duration of three times that expected to release a single Energy unit using the mechanical pushbutton.

7.4. Messages the field BRAIN will accept

The IR emitter provided in the kit can be connected to any unused servo output on your BRAIN. Codes are then sent using the *setServo* command. In the code, servo signal values typically range from zero to 1023. Teams can transmit one of eight possible

codes by simply “setting” the servo/IR-emitter output to one of the values listed in Table 2. For the transmitted codes to be properly received by the field IR receiver, the *setServoRange* command with a width parameter equal to 180 must be issued prior to the first *setServo* command. Depending on the team strategy, the signals may be activated by either the Field Specialist or autonomously. In short, some event (which could be a special joystick combination initiated by the Field Specialist) triggers the robot BRAIN to set the emitter servo output to one of the specific values listed in the Table 2.

The field BRAIN will continuously sample all the IR ports. When a valid code signal endures on an IR communication port for a period of at least one second, then the BRAIN will act on the command. When action is taken the port that received the command will be ignored for a period of five seconds. Whenever a valid code is received at an IR communication port, the energy dispenser arm to the right of the port will momentarily rotate to a new position providing a visual indicator that a code was received.

Table 2. Instruction codes recognized by the field BRAIN.

Intended Instruction to the Field	Nominal Servo Value**	Summary of Action Taken by Field BRAIN
*Register tiebreaker event for my team and pushbutton-only Catalyst release	100	Team tiebreaker is registered Catalyst will not be dispensed until the Catalyst dispenser pushbutton is pressed and it will be dispensed according to the tiebreaker order protocol. Your Catalyst dispenser will not participate in a resource Tsunami and is guarded against Rob (even if the Tsunami or Rob has already begun).
*Register tiebreaker event for my team and timed Catalyst release.	200	Team tiebreaker is registered. After a 10-second delay Catalyst units in your dispenser will be dispensed at 1-second intervals regardless of the tiebreaker order. This code overrides code 100.
Activate Energy dispenser to my right	300	Activate the Energy dispenser for a time period that is likely to dispense three units.
Activate Energy dispenser to my left	400	Activate the Energy dispenser for a time period that is likely to dispense three units.
Activate both Energy dispensers	600	Activate each Energy dispenser for a time period that is likely to dispense three units from each dispenser.
Reset my energy requests to zero	700	Immediately deactivate both Energy dispensers unless one of the neighboring teams has independently activated the same dispenser.
Rob my neighbor	800	Release Catalyst units from the neighboring team's plant (team to the Operator's right). Catalyst units will be released once every 30 seconds until depleted or dispenser is guarded by IR code.
Commodity Tsunami	900	If this instruction is given at three BRAIN ports, then a "resource tsunami" is launched (even if it is a seeding round)

*Important note: Any IR signal received by the field BRAIN through a team's sensor port (EGS leg) will register the team's tiebreaker event if it has not already been registered using the mechanical tiebreaker pushbutton. The specific "Register" instructions (100 and 200) provide a means to register at the EGS without dispensing Energy units.

** requires the servo channel range to be set to 180 using *setServoRange* command

7.5. BRAIN IR Communication Port

An infrared (IR) communication port is located in each of the EGS legs. The port consists of a 2.5" diameter hole drilled 4" from the base of the leg. An IR detector is mounted inside the 4" diameter leg on the wall opposite the hole. The IR detector is positioned slightly above the port centerline to reduce the viewing angle and prevent interference from signals outside the game floor area as shown in Figure 6.

In order to maximize the distance across which commands can be communicated, the LED emitter should be below the centerline of the port. Lower is generally better to increase the range. But, lower will prevent short range communication. Additionally, the emitted light from the LED is directional and has some characteristic divergence angle. Therefore, the light from an incorrectly oriented emitter will not hit the detector regardless of the distance.

The "max ground-level distance" for your local game floor will be published to you after local officials complete testing of the game floor, but is expected to be approximately three feet.

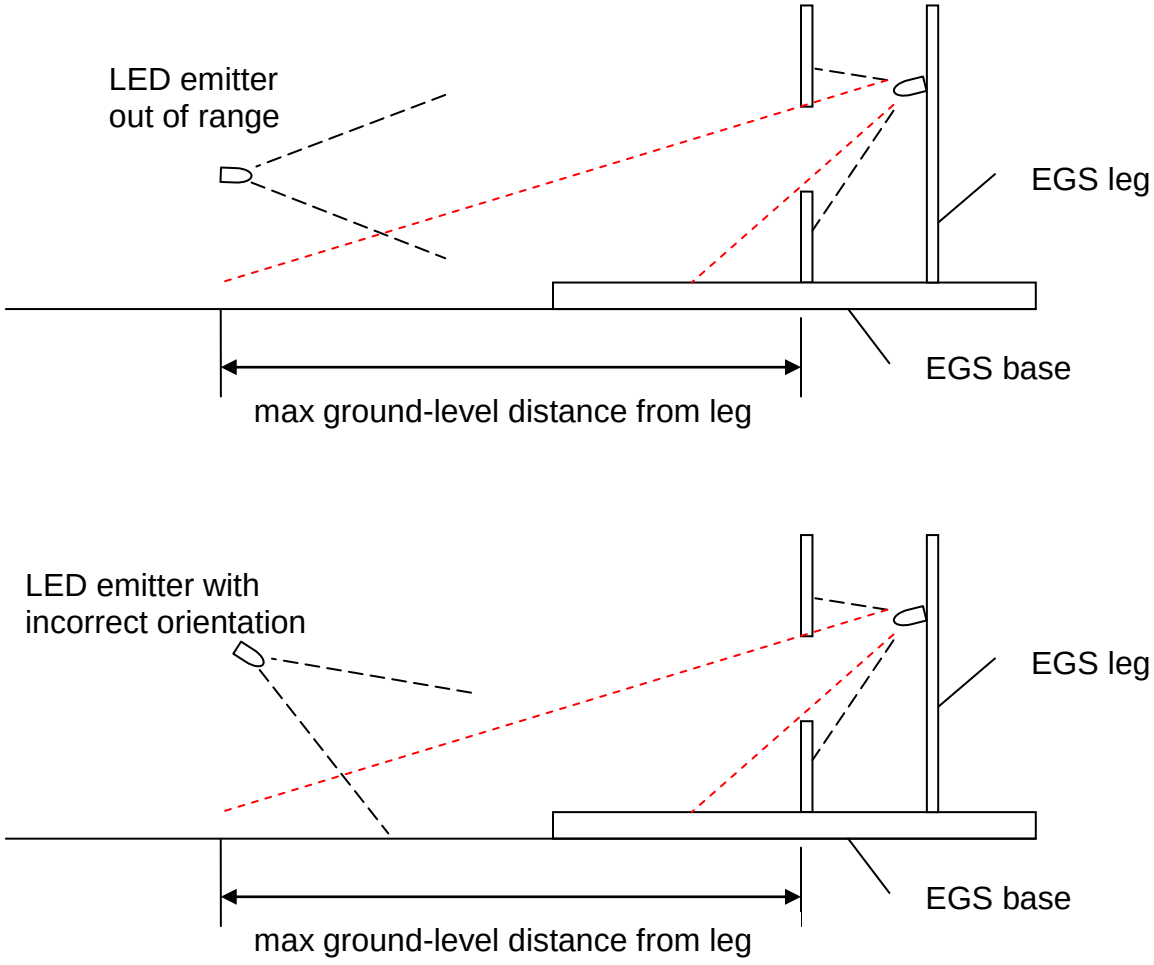

Figure 6. Robot interaction with field IR communication port.

8.0 Match Protocol

Each match shall be three minutes long and is played with a maximum of four teams. If necessary, matches may also be played with fewer than four teams. The scoring software will assign teams to a match and will determine the teams' starting locations relative to the game field.

8.1. Contact Between Robots

Contact between robots is allowed, but is not encouraged.

8.1.1. Destructive Behavior

Destructive Behavior is any action that can be reasonably expected to reduce the operational effectiveness of another robot in future matches regardless of whether, or not, the damage is expected to be easily "fixed" between matches. Any action that may be perceived, by a reasonable person, as Destructive Behavior, may result in disqualification from the match. The referees are considered reasonable people and, in this issue, only their perception counts. If a referee perceives Destructive Behavior, a warning will be immediately issued to the Field Specialist and the effected robots will be physically separated from each other by approximately two feet. The direction of separation is solely at the referee's discretion. Any game piece in the immediate vicinity will be left as near as possible to its position when the infraction first occurred. If a second infraction occurs in a match OR if actual damage is inflicted on the other robot, reducing its operational effectiveness, then the offending team will be disqualified from the match immediately. It is the referee's responsibility to consider the robots' effectiveness before and after the action to determine if a noticeable impact was made. If a team is disqualified from a match, their robot will be turned off, disentangled from the other machines and game floor pieces, and left on the game floor for the remainder of the match. The robot will be left in a configuration and position as near as possible to that when the initial infraction occurred. Other robots interacting with and around a robot immobilized by this rule might also be affected by this rule if the referee perceives they are also in violation of this rule. A team that is disqualified from any two matches for Destructive Behavior will be disqualified from the robot competition, and their remaining scheduled matches will be played with one less robot than intended. They will not be allowed to advance in the competition.

Deploying a blocking device on the game floor is not considered destructive behavior if such a device is passive in nature, even if another robot damages itself by interacting with it. However, if the blocking device employs a sudden release of energy or any other design that can be reasonably expected to damage another machine, then it is considered destructive behavior. Blocking devices deemed to represent Destructive Behavior will be removed from the game floor by the referee as soon as possible.

Examples:

- Cutting a wire is Destructive Behavior and exhibits "actual damage" even though it is probably easily fixed between matches, even if the Field Specialist did not

"intend" to cut a wire. Field Specialists are expected to actively avoid actions that are reasonably expected to result in damage to another robot.

- Placing a passive net or fence on the field is NOT Destructive Behavior even if a robot drives into the net and loses a wheel when trying to get disentangled as long as other Field Specialists have a reasonable opportunity to avoid such devices and pursue some scoring opportunity. However, completely encircling another robot with a fence would be Destructive Behavior. Encircling a game piece with a fence or covering it with a net is not Destructive Behavior even if it is the last available game piece on the field.
- Placing a net on another robot IS Destructive Behavior. The referee would attempt to remove the net and assess if any "actual damage" had occurred.
- Nudging another robot is not necessarily Destructive Behavior. If a solid well-encased robot pushes on another such robot, then a reasonable person would not expect damage. However, plowing into another robot at full speed is Destructive Behavior. Also, inserting your robot arm into the electronics area of another robot where unsecured wires might get unplugged is Destructive Behavior.
- Tipping another robot over is Destructive Behavior. The referee will right the machine and determine if any "actual damage" has occurred.
- If a game piece is released from its starting location and hits another robot, it is NOT Destructive Behavior. Robot designers are already well aware of the potential hazard from falling game pieces and should have factored that into their designs.

8.1.2. Non-Destructive Contact between Robots

The field is divided into four quadrants. Each robot will begin in its "home" quadrant. There are neutral zones between each quadrant of the field. When contact occurs between two robots, the referee will determine the point at which initial contact was made. If the point of contact lies within one of the robots' "home" quadrant, then the other robot will be assessed a 20-second dead controller penalty. During that time, BRAIN controlled actions may continue but the Field Specialist may not operate the RC transmitter (with the exception to halt any unexpected BRAIN activity that may cause damage to the robot, any other robot, or the playing field). If the initial point of contact begins in an area that is neither robots' home quadrant and then contact continues as the robots move into a home quadrant, then no penalty shall be assessed. Anytime contact ceases and then is re-engaged, a new "initial point of contact" is established. So, robots are allowed to venture into other quadrants of the field for any purpose not otherwise disallowed, but if contact with the "home" robot occurs, the visiting robot will be penalized. After the penalty time is completed, the visiting robot must be given a reasonable chance to directly vacate the "home" robot's territory. If the visiting robot is able to move, it must quickly vacate the immediate area of contact (traversing at least 24" before returning). If the referee determines that the visiting robot has not made significant effort to vacate the immediate area, then the robot may be disqualified. If the visitor does not immediately make a clear attempt to completely vacate the territory

(taking shortest possible path to its own home territory), then the “home” robot may re-touch the visiting robot. If the visiting robot is in sole contact with a game piece when immobilized, then the “home” robot cannot touch or take that game piece while the visiting robot is immobilized. If both robots are in contact with the game pieces when the two robots make contact, or if the “home” robot is in sole contact with a game piece when the two robots make contact, then the “home” robot may take the game piece, provided other rules are not violated in doing so.

The intent of this rule is to prevent aggressive blocking tactics and provide each robot a safe area where they have clear advantage over other robots. If a robot chooses to loiter near an opponent’s Processing plant and incur repeated penalties as the “home” robot attempts to place game pieces, then they are allowed to do so as long as the referee perceives significant effort to vacate the immediate area of contact after each penalty and no other rules are violated in doing so.

8.2. Team Starting Locations

During each match, two members from the team will participate and play the roles of processing plant Operator and Field Specialist. At the start of each match, both team members must be in their designated areas. The robot must be in its starting area and in compliance with BEST Generic Game Rules. The starting area for each robot shares the physical area as the offload area (refer to Figure 1). The Operator and Field Specialist must remain in their designated game field positions for the duration of the match. Either of the two may place the robot in its starting position prior to the beginning of the match.

8.3. Additional Restrictions

1. Teams may not retrieve or use any game pieces or robot subassemblies that have touched anything outside of the perimeter of the playing field boundary and outside the Operator area. The game pieces as well as any part of the robot may break the vertical boundary of the playing field but may not touch or come in contact with any object (or person) outside the playing field (with the exception of Operators, robots playing the current match, and referees). The outside surface of the wood is the virtual boundary for the playing field. The top edge of the wood is inside the playing field.

2. It is considered damaging to the game pieces to use a mechanism that penetrates their surface.

3. Game pieces may not be forcibly launched or thrown through the air. There is no penalty for dumping them over obstacles or dropping them from heights or inclined planes. There is no penalty for rolling them.

4. Robots may not touch or remove game pieces already in “scoring” position in another team’s Processing Plant. If a robot already possesses a game piece, it may place it into another team’s Processing Plant as long as no other game piece is affected and no other rule is violated in doing so. Any game piece moved

out of scoring position by a robot, other than the home robot, will be placed back into scoring position by the referee.

5. Robots that contact any part of the EGS on or above the platform deck, or any component installed on or above the platform deck, or any game piece that is in contact with the EGS on or above the platform deck, may be disqualified from the match. If, while a robot is not in contact with the EGS or is in legal contact with the lower deck, a falling game piece bridges the gap between the robot and any illegal portion of the EGS, then the robot will not be in violation as long as its next action moves directly to terminate the illegal contact.

6. The Field Specialist may not directly or indirectly touch or manipulate any game piece or any robot except by normal RC commands to his robot.
7. Robots are allowed to contact the CO_2 units in any way that does not damage the CO_2 and is otherwise allowed by the rules. They are also allowed to interact with the leader line (which is made from the same type of filament as the stratosphere) in any way they choose as long as no other rule is violated while doing so. Robots may not make contact with the traveling filaments that make up the stratosphere.
8. No robot may cross the boundary of the offload area, storage area, or Operator area of another team.

9. Violation of any of the above restrictions may result in a disqualification from the match with loss of any inventory for that match. (The first infraction incurs a 20 second penalty. The second infraction in a match results in disqualification.) Game pieces that are affected during a prohibited activity will be returned (as much as reasonably possible) to the orientation they were in when the prohibited activity began. If a first infraction results in damage to another robot, the team may be immediately disqualified.

9.0 Demonstration (Competition) Protocol

There will be three stages in the demonstration event: a seeding competition, a semi-final competition, and a final competition.

During the seeding competition, each team will participate in up to eight matches against randomly selected opponents. Fewer than eight matches per team may be played when time limitations exist, but all teams will participate in the same number of matches. The team ranking after the seeding competition will be based on the total inventory accumulated/generated during the seeding matches. Teams can drop as many matches as they wish and each team must drop at least one. If they haven't dropped a prior round, then they must drop their final scheduled seeding round and they will not compete in that round. (Teams are encouraged to strategically drop an early round to avoid giving other teams the advantage of playing on a vacant field.) To drop a match, the current Field Specialist must sign the current score card at the beginning of

the current round indicating that the team wants to drop their **previous** match. The team's accumulated inventory and tiebreaker record will be reset to the state immediately prior to the dropped match. The top seven teams from the seeding competition will advance to the semi-final competition. The eighth team for the semi-final competition will be selected from the remaining teams by a single "wild card" match between the four teams with the highest BEST notebook scores. The "wild card" match will have no impact on the teams' accumulated inventory and cannot make use of any previously accumulated inventory. The "wild card" match is, otherwise, conducted according to the seeding rules. The team that collects the highest valued inventory in this stand-alone match will advance to the semi-final rounds. Regional competitions will also advance teams to the semi-finals through one or more wild card match. Again, no resources collected during the wild card match will be added to the team's accumulated inventory.

Teams will enter the semi-final competition phase with the inventory they have accumulated through their scheduled seeding matches with the following exceptions:

- The wild card match has no impact on the total inventory.
- Dropped matches have no impact on the total inventory.
- In conforming to "inherently safe plant design" principles, benzene cannot be carried forward from the seeding matches into the semi-finals. The toxic nature of benzene encourages us to limit real-world inventories wherever possible. This fact will be mimicked in our competition event by simply zeroing all benzene inventories at the beginning of the 1st semi-final round. This inventory adjustment will happen only once and will happen after the semi-final teams have been identified. Inventory accumulation will then continue as usual through the semi-final and final rounds.

During the semi-final competition, each team will participate in a total of three matches based on the rotation shown in Table 3. The team ranking at the end of the semi-finals will be based on the total inventory the team has accumulated through the day's demonstrations (i.e., the results of the seeding matches are also included in the accumulated inventory with the exception of benzene as previously described).

Table 3. Semi-final Match Rotation.

Semi-Final Match	Starting Position			
	Yellow	Blue	Red	Green
1	Seed 4	Seed 1	Seed 5	Seed 8
2	Seed 2	Seed 8	Seed 3	Seed 7
3	Seed 6	Seed 4	Seed 7	Seed 1
4	Seed 3	Seed 2	Seed 4	Seed 5
5	Seed 5	Seed 7	Seed 8	Seed 6
6	Seed 1	Seed 3	Seed 6	Seed 2

Competitions with a team count greater than 32 may choose to advance more teams to the semi-final. In this case, there will be 16 teams in the semi-final. The top 14 teams from the seeding matches will advance plus two wild card teams selected from the other teams by a pair of games involving the eight teams with the highest BEST notebook scores (each team participates in one of the games). The two teams with the highest valued inventory (collected in this single round without the use of any previously accumulated inventory) will get the wild card slots; note that these two teams may come from the same match. Details on the semi-final match rotation for this case will be provided by the hub or regional officials, but each team will still participate in a total of three matches each during the semi-finals.

The four top ranked teams from the semi-final will advance to the final competition where they will participate in three additional matches in the field starting positions shown in Table 4. The final team ranking will be based on the total inventory accumulated throughout the day.

Table 4. Final Match Rotation.

Final Match	Starting Position			
	Yellow	Blue	Red	Green
1	Semi 1	Semi 2	Semi 3	Semi 4
2	Semi 4	Semi 3	Semi 2	Semi 1
3	Semi 3	Semi 1	Semi 4	Semi 2

9.1. Tiebreaker

The average tiebreaker position will be included in the team position calculation for each phase of the competition. The tiebreaker position is determined by the order in which the robots activate the tiebreaker (either pressing the Catalyst dispenser pushbutton or communicating any IR command to the field BRAIN). The tiebreaker position includes only those matches during a particular phase of the competition. For the seeding matches, the tiebreaker position of a team's dropped match will be dropped (along with the score). If the average tiebreaker position does not resolve a tie, the tiebreaker positions of the tied teams will be compared, starting with the most recent match and proceeding to earlier matches (within a competition phase) until a difference is found. The team that activates its tiebreaker mechanism first will place before the other team(s).

10.0 Memo to Team

MEMO

To: All teams participating in the BEST Octane Production Demonstrations

From: BEST Octane Research Team

Date: 9/1/2009

Re: Anticipated Change Orders

Message:

Since the generation of the specification for the 2009 BEST Octane Production Demonstrations, a junior member of the BEST Octane Research Team, Ted, has raised some concerns. Though historically he is only right 20% of the time, we thought it prudent to bring these concerns to your attention because, statistically speaking, one of his concerns are likely to impact your demonstration environment. (Since most engineering projects experience some unanticipated changes in project specification, we really shouldn't be surprised that this issue has arisen). According to this junior member, there are five concerns that may affect your demonstration environment:

1. We are having communication issues with the low-bid foreign supplier that won our water contract. It is unclear whether the H_20 units they shipped come in pairs or not. It is possible that the 16 units available on the field might actually be eight paired sets of racquet balls instead of 16 individual racquet balls. The paired variety consists of two individual balls joined by Velcro. Though Plant Operators will likely be able to easily separate them, your robot might be challenged retrieving them from the field. If the units are paired, the joined pair will assume a starting location originally planned for one of the individual units. The ship is due to arrive a week prior to your event. We'll know more then.
2. When surveying the processing cell conditions, Ted observed that the Catalyst receptacle troughs were installed at various elevations ranging from 2" to 4-3/4" inches above the processing cell floor. We have instructed the contractors to re-install the units at the correct height (top of trough approximately 2" above plant floor), but they may not get to all of them in time. We will know the actual elevation for your demonstrations one week prior to your event.
3. Ted also noted that the plant contractor who installed the Energy receptacles in the processing cell may be dyslexic. Many of the L-shaped receptacles were installed backwards (rotated 180 degrees from the prescribed orientation). We're

sorting it out, but we won't have the full report for your demonstration area until a week prior to your event.

4. Ted's friend, Steve, is instrument specialist and has informed him that the flow meters used when the Benzene Tankers were initially loaded were not properly calibrated. We're not sure if the weight of benzene in the tanker is 16oz or 35oz. We're sure that all the Tankers at a given demonstration area weigh the same, but we won't know the precise weight until we re-weigh them a week before your event.
5. Steve, the instrument specialist, was an integral part of the development team for the proprietary CO_2 stratosphere streaming technology. He has suggested that the CO_2 streaming path is subject to jet stream conditions and cannot be accurately predicted far in the future. Fortunately, only CO_2 in the upper stratosphere is affected. The maximum height of CO_2 may range from 53" down to 42" (measured from the top of the unit to the floor). Jet stream data will be available to make accurate conditions (…you guessed it) one week prior to your demonstration event.

As stated, Ted tends to be right 20% of the time. So, participants are likely to see one of these conditions arise in their demonstration areas. Fortunately, Ted has never been correct twice in one day. Rest assured that all processing plants in your area will be identical to each other and will not change from one match to another at your event. Local coordinators will have the final word concerning each of the five concerns at your local practice-day event. By the way, Ted says these issues may affect regional events as well and final word will be published one week prior to each regional event.