

StarCraft EIS Environment Manual

Harm Griffioen, Danny Plenge, Vincent Koeman

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Chapter 1

Environment

This environment is the first Environment Interface Standard (EIS) compatible agent environment providing full access to StarCraft (Brood War). It brings the challenges of Real-Time Strategy (RTS) games to the field of multi-agent programming whilst also facilitating the development of AI solutions for such games, allowing the development of problem-solving techniques before being applied to similar but more complex real-world problems.

The design of this environment was guided by two conflicting objectives:

1. The environment should facilitate multi-agent systems that operate at a level of *abstraction* that is as high as possible.
2. The environment should facilitate multi-agent system implementations with as many different *strategies* as possible.

In other words, it does not aim for a multi-agent system that operates at the same level of detail as bots written in C or Java, but such a system should in contrast also not consist of a single action ‘*win*’ that will delegate the control to some other subsystem instead. To make optimal use of the reasoning typically employed by cognitive agents, low-level details are handled in the environment whilst still allowing agents sufficiently fine grained control.

RTS games like StarCraft involve very large amounts of units that can come and go during the game and that have to deal with major challenges such as uncertainty and long-term (collaborative) goals, requiring multiple levels of abstraction and reasoning in the vast space of actions and game states that such games have. Therefore, a major factor that was also considered is the performance of the environment; a substantial performance impact caused by for example an enormous amount of percepts will limit the amount of viable implementations (and thus possible strategies).

The remainder of this chapter will demonstrate how to set-up and start a bot with the StarCraft environment using a multi-agent system in the GOAL language. For the latest installation instructions, we refer to:
<https://github.com/eishub/StarCraft/wiki/Install-Guide>

1.1 Chaoslauncher

The Chaoslauncher facilitates plug-ins for StarCraft Brood War, like the *BWAPI Injector* which is necessary for using the BWAPI library that connects our environment to the game. It is also recommended to make use of the *APMAlert* plugin, which shows the current actions per minute of all your units together. It is also recommended to make use of the *W-Mode* plugin. This plugin automatically starts your StarCraft game in windowed mode which is easier for debugging. You can also make use of the *Chaos-Plugin* to make use of its autoreplay function which automatically saves a replay at the end of each game. You can play these replays by first turning off the *BWAPI Injector*. You can then start StarCraft (in the launcher) and select *Single Player* with gametype *Expansion*. Press the ‘Ok’ button and then the ‘Load Replay’ button. If you then open the *Autoreplay* directory in that screen you should be able to see all the replays which are saved by the autoreplay function. Alternatively, view replays in your browser at <http://www.openbw.com/replay-viewer>

1.2 Init Parameters

The StarCraft environment offers multiple configurable items through the init parameters of a mas2g file. When updating any parameters, do not forget to close the Chaoslauncher before launching a new game, as otherwise your changes will not be applied. The example below demonstrates all parameters and their defaults.

```
use "connector.jar" as environment with
  own_race="",
  enemy_race="random",
  map="",
  starcraft_location="C:\StarCraft",
  auto_menu="SINGLE_PLAYER",
  game_type="MELEE",
  game_speed=50.
```

```
debug="false",  
draw_mapinfo="false",  
draw_unitinfo="false",  
invulnernable="false",  
map_agent="true",
```

1.2.1 Own Race

You have to specify the race of your bot. This will make sure that the Chaoslauncher will automatically launch a game with the specified race. You can do this by inserting the following line: *own_race = <RaceName>*, where *<RaceName>* can either be *zerg*, *protoss*, *terran* or *random*. The option *random* will choose one race with a 1/3 chance for each race.

1.2.2 Enemy Race

The enemy race parameter can be used for specifying which race of the game's built-in AI you want to play against. To this end, you can insert *enemy_race=<RaceName>*, where *<RaceName>* can either be *zerg*, *protoss*, *terran*, *random*, *randomtp*, *randomtz*, or *randompz*. The option *random* will choose a race with a 1/3 chance for each race, whilst the other options will choose one of the two indicates races with a 1/2 chance for each race.

1.2.3 Map

You have to specify which map the Chaoslauncher will automatically load when starting the game. This can be done by inserting the following line: *map = <filename>*, where *<filename>* is the exact filename of the map (with extension). Please note that the environment only supports maps in the directory *StarCraft/maps*, and that subdirectories (like *sscait*) should be indicated. Also note that the first time the environment runs on a certain map, it will take some time (around 2 minutes) to generate a datafile for the given map (if not already present in *StarCraft/AI/BWTA*).

1.2.4 StarCraft Location

You have to specify the location of the StarCraft game if it is not installed in *C:/Starcraft*. Using this location, the Chaoslauncher will automatically start when launching a MAS. When the Chaoslauncher is already running, it will not start again until you close it, but this is fine as long as you use the same init parameters (although you have to start the next game manually then).

You can specify the location of StarCraft by inserting *StarCraft_location* = *<FilePath>*, where *<FilePath>* is the absolute path to the StarCraft installation folder.

1.2.5 Auto Menu

The auto menu parameter is used to automatically go through the menus of the game when starting a MAS. This can be used for single player games and multi player games. To use the auto menu function you can insert the following line: *auto_menu=<MenuChoice>*, where *<MenuChoice>* can take the following values:

SINGLE_PLAYER: for a single player game.

Multi_PLAYER: for a multiplayer game.

LAN: for a local multiplayer game.

1.2.6 Game Type

The game type is used to indicate what kind of game the Chaoslauncher should start. Generally, you want this to be the default (*MELEE*), but other game types can be used by inserting *game_type=<GameType>*.

1.2.7 Game Speed

The game speed parameter can be used to set the initial speed of the game when the StarCraft game is launched (the speed can be changed during the game by using the development tool; see the next item). StarCraft makes use of a logical frame rate, which means that the *game_speed* depends on the amount of frames per second (fps) used to update the game. The higher the fps, the faster the game will go. For using the *game_speed* parameter you can insert the following line: *game_speed=<FPS>*, where *<FPS>*. If a number lower than 1 is given, there will be no limit on the amount of FPS used, and the game will thus run as fast as it possibly can.

1.2.8 Debug

The environment offers a development tool for debugging purposes. With this development tool, you can increase or decrease the game speed, enable cheats and toggle the drawing of map and/or unit details in the game. More information about the development tool can be found in 1.4. In order to enable or disable launching the development tool, you can insert *debug=<Boolean>*.

1.2.9 Draw Map Info

This parameter can be used to draw info about the map (bases, regions, chokepoints) without having to enable it the development tool (or without starting the development tool at all) by inserting *draw_mapinfo*=<Boolean>.

1.2.10 Draw Unit Info

This parameter can be used to draw info about units (counts, IDs, health, targets) without having to enable it the development tool (or without starting the development tool at all) by inserting *draw_unitinfo*=<Boolean>.

1.2.11 Invulnerable

The invulnerable parameter can be used to automatically make your units invulnerable from the start of the game (which can also be done manually in the development tool). This can come in handy for testing purposes when you do not want to fight your opponent. To use the invulnerable function you can insert *invulnerable*=<Boolean>.

1.2.12 Map Agent

If enabled, the environment will generate an entity of name and type ‘*mapAgent*’. This entity is not connected to a unit in the game, but will be the only entity to receive all global information: *base*/2, *chokepoint*/6, *enemyrace*/1, *map*/2, *region*/5, *attacking*/2, *constructionSite*/3-4, *enemy*/9, *friendly*/2, *gameframe*/1, *mineralField*/4, *nuke*/2, *resources*/4, *underConstruction*/5, *vepseneGeyser*/5, *winner*/1, and can even take a few actions: *cancel*/1, *debugdraw*/1, *forfeit*/0.

Thus, when the map agent is enabled, all other entities will only receive their local information: *self*/2, *status*/7, *order*/5, *defensiveMatrix*/1, *queueSize*/1, *researching*/1, *unitLoaded*/1, whilst they can of course still take the same actions. The map agent entity can be enabled or disabled with *map_agent*=<Boolean>.

1.3 Entity Types

When defining a launch rule it is important that a correct entity type is used (see 4.4). This value has to be the same type of the StarCraft unit without spaces and where the first letter is uncapitalised. So when you for example want to connect an agent to a **Terran SCV**, this can be done by using the entity type *terranSCV*. Note that each unit type starts with the race of the unit, followed by the exact name of the unit type, and please be aware that the environment will wait in the first game frame until *at least four actions* have been requested, e.g., until all initial workers have called *gather/1*. This will allow all initial agents (including the ‘*mapAgent*’) to fully start-up (and possible execute a few cycles already) before the game starts.

```
define myAgent as agent {
    ...
}

launchpolicy {
    when type = terranSCV launch myAgent.
}
```

With mind control (an advanced Protoss ability), units from other races can be taken over. These units will also get an entity. A possible way to accomodate such entities is by making sure any other unit type is connected to a generic agent through a wildcard launch rule at the end of your mas2g:

```
when type=* launch ...
```

1.4 The Development Tool

The development tool can be automatically launched by using the *debug* init parameter. It provides several actions that are useful for debugging purposes.

1.4.1 Game Speed

The Game Speed slider can be found at the top of the development tool window. When the slider is used, the speed of the game will be changed immediately. The slider start on a value of 50 fps (this will not reflect the *game_speed* init parameter). The slowest speed is 20 fps, and from there you can set it as fast as you want. Please note that the agents are supposed to play at 50 fps, which is the default game speed for AI tournaments. When the speed is set to more than 100 fps, the agents can react slower than they would on the tournament speed. Setting the game speed to more than 100 fps should thus only be used for quick testing purposes.

1.4.2 Cheat Actions

The development tool offers 3 buttons which instantly enable StarCraft cheats. Note that these cheats should be used for testing purposes only. The first cheat is called: *Give resources* which gives the player 10000 minerals and 10000 gas. The second cheat is called: *Enemy attacks deal 0 damage* which makes the units of the player immune for damage (note: this can be automatically enabled with the init parameter *invulnerable*). The last cheat is called: *Show map* which makes the whole map visible for the player. Note that all your agents will then also perceive everything on the map.

1.4.3 Draw Actions

The development tool can also be used to show map or unit details in StarCraft itself. There are 2 buttons to this end, reflecting the matching *draw_mapinfo* and *draw_unitinfo* parameters. Please see the information above on these parameters for more information.

Chapter 2

Percepts

This chapter lists all the percepts that are generated by the StarCraft environment, which vary per unit (also see the *map_agent* init parameter in the previous chapter). For the implementation of these percepts in your agent program, we refer to the GOAL programming guide.

In order to reduce the number of percepts, one generic guideline used in this environment is to *only create percepts for information that changes in a single match or between matches*. Even though there is a lot of static information in a game like StarCraft, like the type of a unit (i.e., biological or mechanic), what a certain unit costs to produce, or the units a certain building can produce, this information remains the same for any execution of any agent system, and is thus much better suited to be encoded in the agent system itself. To this end, a Prolog file is supplied in the environment's installer that contains a large list of predicates representing static information about the game. The predicates available in this file are listed at the end of this section. Note that it is not expected that agents 'hard-code' information about specific maps on which matches can be played, and thus agents will need to be informed about changes between matches (i.e., map-specific information).

Another guideline used in this environment is that *no data is sent through percepts that can either be calculated based on other data, (e.g., the number of friendly units by adding the amount of percepts about their status) or retrieved from other agents (e.g., the position of a friendly unit)*. Relaying such information through messaging(channels) is usually much more efficient, as one can then selectively choose at which times and to which units to send information, as opposed to percepts always being sent to certain units even when they do not require them (at that time) for their decision making.

2.1 Global Static Percepts

These percepts represent global information (i.e., not specific to a certain unit) that will not change during a match. When the map agent is enabled, it will be the only entity to receive these percepts when started. Otherwise, all entities will receive these percepts when started. Note that all coordinates (X,Y) reflect tile positions; one such tile is actually 16 by 16 pixels. Moreover, Zerg units that morph (or Protoss units that mege) into a different type of unit will keep the same ID (of one of the units).

2.1.1 base/4

Description Information about all base locations on the map. These are possible construction sites for resource centers (or spawning sites for the initial center).

Type Send once

Syntax `base(<IsPossibleStart>,<X>,<Y>,<Region>)`

Example `base(true, 28, 32, 8)`

Parameters	<IsPossibleStart>	Indicates whether the location is a potential starting location or not (i.e., there are 2 on a 2-player map and 4 on a 4-player map).
	Type	Boolean
	Range	[true,false]
	<X>	The x-coordinate of the base location.
	Type	Integer
	Range	[0-∞]
	<Y>	The y-coordinate of the base location.
	Type	Integer
	Range	[0-∞]
	<Region>	The region the base is located in. Can for example be used to find matching mineral patches and geysers.
	Type	Integer
	Range	[1-∞]

2.1.2 chokepoint/6

Description Information about all chokepoints on the map. These are the narrow points on the map where only a limited amount of units can go through at the same time (depending on the specific chokepoint's width). All regions are connected through chokepoints.

Type Send once

Syntax `chokepoint(<X1>,<Y1>,<X2>,<Y2>,<Region1>,<Region2>)`

Example `chokepoint(12, 15, 14, 17, 1, 2)`

Parameters	<X1>	The x-coordinate of the first side.
	Type	Integer
	Range	[0-∞]
	<Y1>	The y-coordinate of the first side.
	Type	Integer
	Range	[0-∞]
	<X2>	The x-coordinate of the second side.
	Type	Integer
	Range	[0-∞]
	<Y2>	The y-coordinate of the second side.
	Type	Integer
	Range	[0-∞]
	<Region1>	The ID of the first region.
	Type	Integer
	Range	[1-∞]
	<Region2>	The ID of the second region.
	Type	Integer
	Range	[1-∞]

2.1.3 enemyRace/1

Description The race of the opponent (it is assumed there is only one).
 Type Send once
 Syntax `enemyRace(<Race>)`
 Example `enemyRace(protooss)`
 Example When playing against a random race (*<Race>=unknown*), you can use something like:

```
if bel(enemyRace(unknown), enemy(Type,_,_,_,_)) ,
sub_string(Type,0,1,_,Race)) then {
  if bel(Race = "Z") then delete(enemyRace(unknown))
  + insert(enemyRace(zerg)).
  if bel(Race = "P") then delete(enemyRace(unknown))
  + insert(enemyRace(protooss)).
  if bel(Race = "T") then delete(enemyRace(unknown))
  + insert(enemyRace(terran)).
}
```

Parameters	<Race>	The enemy race.
	Type	String
	Range	<i>[terran,protooss,zerg,unknown]</i>

2.1.4 map/2

Description The width and the height of the map (in tiles).
 Type Send once
 Syntax `map(<Width>,<Height>)`
 Example `map(96, 128)`

Parameters	<Width>	The width of the map (no. of horizontal tiles).
	Type Range	Integer [1-∞]
	<Height>	The height of the map (no. of vertical tiles).
	Type Range	Integer [1-∞]

2.1.5 region/5

Description Information about all regions on the map. Regions are connected by chokepoints and can be on high or low ground.

Type Send once

Syntax `region(<Id>,<CenterX>,<CenterY>,<Height>,<ConnectedRegionsList>)`

Example `region(12, 15, 14, 17, [1,2])`

Parameters

<Id> Type Range	The ID of the region. Integer [1-∞]
<CenterX> Type Range	The x-coordinate of the center of the region. Integer [0-∞]
<CenterY> Type Range	The y-coordinate of the center of the region. Integer [0-∞]
<Height> Type Range	The height of the region. Integer [0-∞]
<ConnectedRegionsList> Type	A list of regions (by ID) that are connected to this region (i.e., through chokepoints). List

2.2 Global Dynamic Percepts

These percepts represent information that changes during a match, but is still global to the match (i.e., not specific to a certain unit). When the map agent is enabled, it will be the only entity to receive these percepts during the match. Otherwise, all entities (or all workers for the *constructionSite/3-4* percept) will receive these percepts during the match.

2.2.1 attacking/2

Description All enemy units that are attacking / going to attack and the corresponding units they have targeted (which can be friendly when e.g. healing or repairing).

Type Send always

Syntax `attacking(<Id>,<TargetId>)`

Example `attacking(123, 177)`

Parameters	<Id> Type Range	The ID of the enemy unit that is attacking. Integer [1- ∞]
	<TargetId> Type Range	The ID of the unit which is being targeted. This unit is mostly friendly, but can also be an enemy for e.g. heals or repairs. Integer [1- ∞]

2.2.2 constructionSite/3-4

Description	All visible and non-obstructed locations at which buildings can potentially be constructed. Such construction sites are squares containing 4 tiles, as the minimum size of any building is 2 by 2 tiles. This information is updated every 50 game frames. Note that resource centers require a minimum distance to mineral patches and geysers (which the locations as indicated by <i>base/4</i> conform to for example).
Type	Send always
Syntax	(Protoss) <code>constructionSite(<X>,<Y>,<Region>,<InPylonRange>)</code> (Zerg) <code>constructionSite(<X>,<Y>,<Region>,<OnCreep>)</code> (Terran) <code>constructionSite(<X>,<Y>,<Region>)</code>
Example	<code>constructionSite(66, 98, 4, false)</code> <code>constructionSite(66, 98, 4)</code>

Parameters	<X> Type Range	The x-coordinate of the construction site. Integer [0-∞]
	<Y> Type Range	The y-coordinate of the construction site. Integer [0-∞]
	<Region> Type Range	The region the construction site is in. Integer [1-∞]
	<InPylonRange> Type Range	Indicates whether the construction site is in range of a pylon (for Protoss only). Boolean [True-False]
	<OnCreep> Type Range	Indicates whether the construction site is on creep (for Zerg only). Boolean [True-False]

2.2.3 enemy/9

Description Information about all visible (living) enemy units. Note that this also includes unfinished units (like buildings under construction) or cloaked units that cannot be attacked until they are detected (see *<Conditions>*).

Type Send always

Syntax `enemy(<Id>,<Type>,<Health>,<Shield>,<Energy>,<Conditions>,<X>,<Y>,<Region>)`

Example `enemy(12, 'Zerg Overlord', 200, 100, 0, [flying], 120, 96, 3)`

Parameters	<Id>	The ID of the unit.
	Type	Integer
	Range	[1–∞]
	<Type>	The type of the unit. This consists of a string with the race of the unit and the name of the unit parted by a space.
	Type	String
	Range	See Section 4.4
	<Health>	The current amount of health of the unit.
	Type	Integer
	Range	[1–<maxHealth>] where <maxHealth> is the maximum health of the given unit type.
	<Shield>	The current amount of shields of the unit.
	Type	Integer
	Range	[0–<maxShield>] where <maxShield> is the maximum shield of the given unit type.
	<Energy>	The current amount of energy of the unit.
	Type	Integer
	Range	[0–<maxEnergy>] where <maxEnergy> is the maximum shield of the given unit type.
	<Conditions>	A list representing the current conditions of the unit. Each unit can have multiple or no conditions depending on the unit and situation. Note that not all conditions are available for enemies.
	Type	List of Strings
	Range	See Section 2.5
	<X>	The x-coordinate of the unit.
	Type	Integer
	Range	[0–∞]
	<Y>	The y-coordinate of the unit.
	Type	Integer
	Range	[0–∞]
	<Region>	The region the unit is in. Can be 0 if the unit is on a chokepoint (and thus ‘in-between’ regions).
	Type	Integer
	Range	[0–∞]

2.2.4 friendly/2

Description Information about all (living) units of the player. Note that this also includes unfinished units that do not have an entity and thus agent yet (like buildings under construction), see also the *underConstruction/5* percept.

Type Send always

Syntax `friendly(<Id>,<Type>)`

Example `friendly(26, 'Protoss Gateway')`

Parameters	<Id>	The ID of the unit.
	Type Range	Integer [1–∞]
	<Type>	The type of the unit. This consists of a string with the race of the unit and the name of the unit parted by a space.
	Type Range	String See Section 4.4

2.2.5 gameframe/1

Description The current game frame, sent per 50 frames (which is also the interval at which construction sites are updated). For more information see Section 1.2.7.

Type Send on change

Syntax `gameframe(<Number>)`

Example `gameframe(150)`

Parameters	<Number>	The game frame count in increments of 50.
	Type Range	Integer [0–∞]

2.2.6 mineralField/5

Description Information about visible (non-empty) mineral fields.
 Type Send always
 Syntax `mineralField(<Id>,<Resources>,<X>,<Y>,<Region>)`
 Example `mineralField(57, 5000, 6, 22, 32)`

Parameters	<table> <tr> <td><Id> Type Range</td><td>The ID of the mineral field. Integer [1–∞]</td></tr> <tr> <td><Resources> Type Range</td><td>The amount of minerals left in the field. Can be 0 for mineral fields that obstruct e.g. chokepoints. Integer [0–5000]</td></tr> <tr> <td><X> Type Range</td><td>The x-coordinate of the mineral field. Integer [0–∞]</td></tr> <tr> <td><Y> Type Range</td><td>The y-coordinate of the mineral field. Integer [0–∞]</td></tr> <tr> <td><Region> Type Range</td><td>The region the mineral field is in. Integer [1–∞]</td></tr> </table>	<Id> Type Range	The ID of the mineral field. Integer [1–∞]	<Resources> Type Range	The amount of minerals left in the field. Can be 0 for mineral fields that obstruct e.g. chokepoints. Integer [0–5000]	<X> Type Range	The x-coordinate of the mineral field. Integer [0–∞]	<Y> Type Range	The y-coordinate of the mineral field. Integer [0–∞]	<Region> Type Range	The region the mineral field is in. Integer [1–∞]
<Id> Type Range	The ID of the mineral field. Integer [1–∞]										
<Resources> Type Range	The amount of minerals left in the field. Can be 0 for mineral fields that obstruct e.g. chokepoints. Integer [0–5000]										
<X> Type Range	The x-coordinate of the mineral field. Integer [0–∞]										
<Y> Type Range	The y-coordinate of the mineral field. Integer [0–∞]										
<Region> Type Range	The region the mineral field is in. Integer [1–∞]										

2.2.7 nuke/2

Description Indicates that a nuclear strike will land on the given position.
 Type Send always
 Syntax `nuke(<X>,<Y>)`
 Example `nuke(22, 37)`

Parameters	<table> <tr> <td><X> Type Range</td><td>The x-coordinate of the incoming nuclear strike. Integer [0–∞]</td></tr> <tr> <td><Y> Type Range</td><td>The y-coordinate of the incoming nuclear strike. Integer [0–∞]</td></tr> </table>	<X> Type Range	The x-coordinate of the incoming nuclear strike. Integer [0–∞]	<Y> Type Range	The y-coordinate of the incoming nuclear strike. Integer [0–∞]
<X> Type Range	The x-coordinate of the incoming nuclear strike. Integer [0–∞]				
<Y> Type Range	The y-coordinate of the incoming nuclear strike. Integer [0–∞]				

2.2.8 resources/4

Description	The amount of minerals, gas and supply available to the player (i.e. shared by all units). Note that in order to avoid halves, supply is multiplied by 2 throughout this interface, so 10 supply in-game corresponds with 20 supply in this environment.
Type	Send on change
Syntax	<code>resources(<Minerals>,<Gas>,<UsedSupply>,<TotalSupply>)</code>
Example	<code>resources(350, 100, 25, 41)</code>

Parameters	<Minerals> Type Range	The current amount of minerals available. Integer [0-∞]
	<Gas> Type Range	The current amount of gas available. Integer [0-∞]
	<UsedSupply> Type Range	The amount of supply that is in use. Integer [0-400]
	<TotalSupply> Type Range	The total amount of supply that is available. Note that usually <TS> is always greater or equal to <CS>, but this can change when supply providing units are killed. Integer [0-400]

2.2.9 underConstruction/5

Description Indicates a new friendly unit that is under construction (i.e. by a worker or through morphing). This percept allows getting data about unfinished units that do not have an entity (and thus agent) yet.

Type Send always

Syntax `underConstruction(<Id>,<Vitality>,<X>,<Y>,<Region>)`

Example `underConstruction(44, 74, 22, 37, 2)`

Parameters	<Id> Type Range	The ID of the unit. Integer [1–∞]
	<Vitality> Type Range	The combined amount of health and shield of the unit. This generally increases whilst the unit is nearing completion, though it can simultaneously be brought done as well by enemy attacks. Integer [0–∞]
	<X> Type Range	The x-coordinate of the unit. Integer [0–∞]
	<Y> Type Range	The y-coordinate of the unit. Integer [0–∞]
	<Region> Type Range	The region the unit is in. Can be 0 if a morphing unit is on a chokepoint (and thus ‘in-between’ regions). Integer [0–∞]

2.2.10 vespeneGeyser/5

Description Information about visible (though possibly empty) vespene geysers. Empty geysers can still be mined from, though at a reduced rate.

Type Send always

Syntax `vespeneGeyser(<Id>,<Resources>,<X>,<Y>,<Region>)`

Example `vespeneGeyser(57, 5000, 22, 32, 6)`

Parameters	<Id> Type Range	The ID of the vespene geyser. Integer [1-∞]
	<Resources> Type Range	The amount of gas left in the vespene geyser. Integer [0-∞]
	<X> Type Range	The x-coordinate of the vespene geyser. Integer [0-∞]
	<Y> Type Range	The y-coordinate of the vespene geyser. Integer [0-∞]
	<Region> Type Range	The region the vespene geyser is in. Integer [1-∞]

2.2.11 winner/1

Description Indicates if the player has won or lost at the end of the game. Used mainly for automated testing purposes.

Type Send once

Syntax `winner(<HasWon>)`

Example `winner(true)`

Parameters	<HasWon>	Whether the player has won or not.
	Type	Boolean
	Range	[true,false]

2.3 Generic Unit Percepts

These percepts are generated for all individual units in the game (thus excluding the mapAgent if it is enabled). Although the *self/2* percept represents static information that does not change during the match, the *status/7* and the *order/3* percepts are updated frequently.

2.3.1 self/2

Description Indicates the ID and type of the unit itself.

Type Send once

Syntax `self(<Id>,<Type>)`

Example `self(21, 'Terran SCV')`

Parameters	<Id>	The ID of the unit.
	Type	Integer
	Range	[1-∞]
	<Type>	The type of the unit. The type of a unit consists of a string with the race of the unit and the name of the unit parted by a space. See Section 4.4 for the list of all the unit types.
	Type	String

2.3.2 status/7

Description The current amount of health, shield and energy of the unit.
The **status** percept also shows the conditions of the unit and its current position.

Type Send on change

Syntax `status(<Health>,<Shield>,<Energy>,<Conditions>,<X>,<Y>,<Region>)`

Example `status(250, 0, 0, [moving, carrying], 24, 36, 1)`

Parameters	<Health> Type Range	The current amount of health of the unit. Integer [0-<MaxHealth>] where <MaxHealth> is the maximum health of the given unit.
	<Shield> Type Range	The current amount of shields of the unit. Integer [0-<MaxShield>] where <MaxShield> is the maximum shield of the given unit.
	<Energy> Type Range	The current amount of energy of the unit. Integer [0-<MaxEnergy>] where <MaxEnergy> is the maximum energy of the given unit.
	<Conditions> Type Range	A list representing the current conditions of the unit. Each unit can have multiple or no conditions depending on the unit and situation. List of Strings See Section 2.5
	<X> Type Range	The x-coordinate of the unit. Integer [0-∞]
	<Y> Type Range	The y-coordinate of the unit. Integer [0-∞]
	<Region> Type Range	The region the unit is in. Can be 0 if the unit is on a chokepoint (and thus 'in-between' regions). Integer [0-∞]

2.3.3 order/5

Description Indicates what the unit is ordered to do. A unit always has an order (e.g. even 'Nothing' is an order).
 Type Send on change
 Syntax `order(<Primary>,<TargetUnit>,<TargetX>,<TargetY>,<Secondary>)`
 Example `order('AttackMove', -1, 34, 8, 'None')`

Parameters	<div> <Primary> Type Range </div>	<div> The primary order of the unit. Some actions are converted into race or unit specific orders. String See https://bwapi.github.io/namespace_b_w_a_p_i_1_1_orders.html </div>
	<div> <TargetUnit> Type Range </div>	<div> The ID of the unit the order is targeted at if any; -1 otherwise. Integer [-1-∞] </div>
	<div> <TargetX> Type Range </div>	<div> The X coordinate of the position the order is targeted at if any; -1 otherwise. Integer [-1-∞] </div>
	<div> <TargetY> Type Range </div>	<div> The Y coordinate of the position the order is targeted at if any; -1 otherwise. Integer [-1-∞] </div>
	<div> <Secondary> Type Range </div>	<div> The secondary order of the unit. This is usually 'None', but is used when for example a Protoss Carrier is both moving and producing units. String See https://bwapi.github.io/namespace_b_w_a_p_i_1_1_orders.html </div>

2.4 Unit-Specific Percepts

These percepts are generated only for specific units in the game. All of these (dynamic) percepts represent information that can change during the match.

2.4.1 defensiveMatrix/1

Description	Information about how much health the defensive matrix has left on the unit. This only applies to friendly Terran units having received such a matrix from a Science Vessel.							
Type	Send always							
Syntax	defensiveMatrix(<Health>)							
Example	defensiveMatrix(200)							
Parameters	<table><tr><td><Health></td><td>The amount of health left for the defensive matrix.</td></tr><tr><td>Type</td><td>Integer</td></tr><tr><td>Range</td><td>[0–250]</td></tr></table>	<Health>	The amount of health left for the defensive matrix.	Type	Integer	Range	[0–250]	
<Health>	The amount of health left for the defensive matrix.							
Type	Integer							
Range	[0–250]							

2.4.2 queueSize/1

Description	The number of units that are in the queue of any production unit (e.g. including Protoss Reavers and Carriers). Zerg Hatchery/Lair/Hive: The number of of available larva. Terran Nuclear Silo: 1 if a nuke is ready (after a corresponding <i>train/1</i> action); 0 otherwise.							
Type	Send on change							
Syntax	queueSize(<Size>)							
Example	queueSize(2)							
Parameters	<table><tr><td><Size></td><td>See description.</td></tr><tr><td>Type</td><td>Integer</td></tr><tr><td>Range</td><td>[0–5]</td></tr></table>	<Size>	See description.	Type	Integer	Range	[0–5]	
<Size>	See description.							
Type	Integer							
Range	[0–5]							

2.4.3 researching/1

Description Indicates which technology or upgrade is being researched by the unit (i.e. a building).

Type Send always

Syntax `researching(<Type>)`

Example `researching('Stim Packs')`

Parameters	<Type>	The technology or upgrade that is being researched.
	Type	String
	Range	See Section 4.2 and Section 4.3
	Note	The level of an upgrade type (if applicable) is not included.

2.4.4 unitLoaded/1

Description Indicates which unit(s) are loaded inside the loadable unit (e.g. a Terran Bunker or a Protoss Shuttle).

Type Send always

Syntax `unitLoaded(<Id>)`

Example `unitLoaded(154)`

Parameters	<Id>	The ID of the loaded unit.
	Type	Integer
	Range	[0–∞]

2.5 Conditions

This section lists the conditions a unit can potentially have. The race-specific conditions are either only applicable to or caused by units from that race.

2.5.1 Workers

carrying	Indicates when the worker unit is carrying minerals or vespene gas.
constructing	Shows that the worker unit is busy constructing a building.
gathering	Show that the worker unit is busy gathering minerals or vespene gas.
repairing	Shows that the (Terran) worker unit is busy repairing a building.

2.5.2 Generic

attacking	Indicates when a unit is attacking an other unit (includes medic heal).
beingConstructed	Indicates that a unit is incomplete (includes morphing).
cloaked	Indicates that a unit is cloaked.
coolingDown	Indicates that a unit cannot attack due to cooldown.
detected	Indicates that an enemy cloaked/burrowed unit has been detected (and thus can be attacked).
flying	Indicates that a unit is flying.
following	Indicates that a unit is following an other unit.
holding	Indicates that a unit is holding a position.
idle	Indicates that the unit is idle (not doing anything).
loaded	Indicates that a unit is loaded (i.e. has one or more units in it).
moving	Indicates that a unit is moving.
patrolling	Indicates that a unit is patrolling between 2 positions.
underAttack	Indicates that a unit is under attack.

2.5.3 Zerg

acidSpored	Indicates that a unit is under Acid Spores from a Zerg Defiler.
burrowed	Indicates that a Zerg unit is burrowed.
darkSwarmed	Indicates that a unit is under a Dark Swarm from a Zerg Defiler.
ensnared	Indicates that a unit is ensnared by a Zerg Queen.
morphing	Indicates that a Zerg unit is morphing.
parasited	Indicates that a unit is parasited by a Zerg Queen.
plagued	Indicates that a unit is plagued by a Zerg Defiler.

2.5.4 Terran

<addonName>	Indicates that an addon of a Terran building is present.
beingHealed	Indicates that a Terran unit is being healed by a Medic or repaired by a SCV.
blinded	Indicates that a unit is blinded by a Terran Medic.
defenseMatrixed	Indicates that a Terran unit has a defensive matrix on it (from a Science Vessel).
hasMines	Indicates that a Terran Vulture has at least one Spider Mine.
irradiated	Indicates that a unit is irradiated by a Terran Science Vessel.
lifted	Indicates that a Terran building is lifted (and thus can move).
lockDowned	Indicates that a unit is under lockdown by Terran Ghost.
nukeReady	Indicates that a Terran Nuclear Silo is ready to launch a Nuclear Missile.
sieged	Indicates that a Terran Siegetank is in siegemode.
stimmed	Indicates that a Terran Firebat or Marine is stimmed.

2.5.5 Protoss

<code>disruptionWebbed</code>	Indicates that a unit is in a disruption web from a Protoss Corsair.
<code>hasScarabs</code>	Indicates that a Protoss Reaver has at least one Scarab.
<code>maelstrommed</code>	Indicates that a unit is maelstrommed by a Protoss Dark Archon.
<code>stasised</code>	Indicates that a unit is stuck in stasis from a Protoss Arbiter.
<code>underStorm</code>	Indicates that a unit is under a storm from a Protoss High Templar.
<code>unpowered</code>	Indicates that a Protoss building unit is no longer powered by a pylon (e.g. a Photon Cannon then no longer functions).

Chapter 3

Actions

This chapter lists all the actions that are usable in the StarCraft environment, which vary per unit.

3.1 All Units

The following actions can be executed by any unit.

3.1.1 `cancel/1`

Description	Cancel the construction or morphing of a unit.
Syntax	<code>cancel(<TargetId>)</code>
Parameters	<code><TargetId></code> : The ID of the unit of which the construction or morphing should be cancelled.
Pre	The targeted unit is incomplete (not fully constructed or morphed).
Post	The targeted unit's construction or morphing will be cancelled; resources will be refunded (and for Zerg the original unit will be restored).
Note	It makes most sense for the <i>'mapAgent'</i> to execute this.

3.1.2 debugdraw/1

Description	Draw text above a unit in the game window.
Syntax	<code>debugdraw(<Text>)</code>
Parameters	<code><Text></code> : The text(string) that should be drawn.
Pre	-
Post	The given text will be drawn above the unit (i.e., it will stay with the unit) in the game window. If the given text is empty, the drawing will be cancelled.
Note	For the <i>'mapAgent'</i> , the text will be drawn on a fixed position on the left top of the game window.

3.1.3 forfeit/0

Description	Forfeit the game.
Syntax	<code>forfeit</code>
Pre	The game is in progress.
Post	The game ends with a loss for the player.
Note	It makes most sense for the <i>'mapAgent'</i> to execute this.

3.1.4 morph/1 (Zerg only)

Description	Morph a unit into another unit(type).
Syntax	<code>morph(<Type>)</code>
Parameters	<code><Type></code> : The type to morph into. See 4.4.
Pre	The unit is capable of morphing into the given unit type.
Post	The unit's corresponding agent terminates and a new agent is created for the new unit when it is completed (with the same ID).

3.2 Buildings

The actions in this section can only be executed by buildings (or by some special units that can be loaded or that can produce units of their own).

3.2.1 buildAddon/1 (Terran only)

Description	Build an addon.
Syntax	<code>buildAddon(<Name>)</code>
Parameters	<code><Name></code> : The name of the addon that is to be constructed. See 4.4.
Pre	The building is capable of building the addon and does not already have an addon.
Post	The building starts constructing the addon.

3.2.2 cancel/0

Description	Cancel the last train or research action.
Syntax	<code>cancel</code>
Pre	The unit is training, researching, or constructing an add-on (Terran-only).
Post	The last train, research, or add-on build is cancelled; the resources are refunded.

3.2.3 land/2 (Terran only)

Description	Land a lifted building on a given location.
Syntax	<code>land(<X>, <Y>)</code>
Parameters	<code><X></code> : The x-coordinate of the chosen landing location. <code><Y></code> : The y-coordinate of the chosen landing location.
Pre	The unit is currently lifted and the landing location is visible, not obstructed, and fitting for the building.
Post	The unit moves to (if needed) and lands on the chosen location. It reconnects with any addon if applicable.

3.2.4 lift/0 (Terran only)

Description	Lift a building into the air.
Syntax	<code>lift</code>
Pre	The unit is capable of lifting and is not currently performing any other action.
Post	The building lifts into the air.

3.2.5 load/2

Description	Load a given unit into the unit.
Syntax	<code>load(<Id>)</code>
Parameters	<code><Id></code> : The ID of the unit to load into this unit.
Pre	The unit is capable of loading the targeted unit and has enough space provided for the targeted unit.
Post	The targeted unit moves towards to the loadable unit and loads into it.

3.2.6 research/1

Description	Research a tech or upgrade.
Syntax	<code>research(<Type>)</code>
Parameters	<code><Type></code> : The name of the tech or upgrade. See 4.3 and 4.2.
Pre	The unit is capable of researching the given tech or upgrade.
Post	The unit starts researching the given tech or upgrade.
Note	The level of an upgrade type (if applicable) is optional; this stacks automatically.

3.2.7 train/1

Description	Train a unit.
Syntax	<code>train(<Type>)</code>
Parameters	<code><Type></code> : The type of unit to train. See 4.4.
Pre	The unit is capable of producing the given unit.
Post	The unit starts producing the given unit.

3.2.8 unload/1

Description	Unload a loaded unit from the unit.
Syntax	<code>unload(<Id>)</code>
Parameters	<code><Id></code> : The ID of the unit to unload from this unit.
Pre	The given unit is currently loaded into the unit.
Post	The targeted unit is unloaded from the unit.

3.2.9 unloadAll/0

Description	Unload all loaded units from the unit.
Syntax	<code>unloadAll</code>
Pre	There are units currently loaded into the unit.
Post	All loaded units are unloaded from the unit.

3.3 Moving Units

The action in this section can only be executed by moving units (i.e. non-buildings or lifted Terran buildings).

3.3.1 ability/1

Description	Use a (researched) ability.
Syntax	<code>ability(<Type>)</code>
Parameters	<code><Type></code> : The type of technology to use. See 4.2.
Pre	The given TechType is researched and the unit is capable of performing the ability (without a target unit or location).
Post	The unit performs the ability.
Note	Behaviour that can be toggled on and off (e.g. Burrow/-Cloak/Siege) is also executed by using this action (i.e. once for enabling and then again for disabling).

3.3.2 ability/2

Description	Use a (researched) ability on a target unit.
Syntax	<code>ability(<Type>, <Target>)</code>
Parameters	<code><Type></code> : The type of technology to use. See 4.2. <code><Target></code> : The target to use the technology on.
Pre	The given TechType is researched, the unit is capable of performing the ability (with some target unit), and the target unit is visible
Post	The unit performs the ability on the target unit.

3.3.3 ability/3

Description	Use a (researched) ability on a location.
Syntax	<code>ability(<Type>, <X>, <Y>)</code>
Parameters	<code><Type></code> : The type of technology to use. See 4.2. <code><X></code> : The x-coordinate of the chosen location. <code><Y></code> : The y-coordinate of the chosen location.
Pre	The chosen TechType is researched, the unit is capable of performing the ability (with some target location), and the location is visible.
Post	The unit performs the ability on the given location.

3.3.4 attack/1

Description	Attack a given unit.
Syntax	<code>attack(<TargetId>)</code>
Parameters	<code><TargetId></code> : The ID of the unit that should be attacked.
Pre	The unit is attack capable and the targeted unit is visible and reachable.
Post	The targeted unit is being attacked by your unit. The unit will keep moving towards the enemy unit in order to attack it as long as it is visible and alive.
Note	Terran Medics can use this action to heal friendly units; they cannot attack enemies.

3.3.5 attack/2

Description	Move to a given location and attack everything on the way.
Syntax	<code>attack(<X>,<Y>)</code>
Parameters	<X>: The x-coordinate of the chosen location. <Y>: The y-coordinate of the chosen location.
Pre	The unit is attack capable.
Post	The unit moves to the chosen location (or as close as it can get) whilst attacking any enemy unit that it encounters along the way; all such enemy units will be chased until they are no longer visible or alive.
Note	Terran Medics will heal any friendly units they encounter.

3.3.6 follow/1

Description	Follow a given unit.
Syntax	<code>follow(<given>)</code>
Parameters	<given>: The ID of the unit that should be followed.
Pre	The targeted unit is visible.
Post	The unit follows the selected unit; any enemy will be ignored (i.e. the unit will not automatically attack anything).

3.3.7 hold/0

Description	Hold a position.
Syntax	<code>hold</code>
Pre	-
Post	The unit will hold its current position; any enemy will be ignored (i.e. the unit will not automatically attack anything).

3.3.8 move/2

Description	Move to a given location.
Syntax	<code>move(<X>,<Y>)</code>
Parameters	<X>: The x-coordinate of the chosen location. <Y>: The y-coordinate of the chosen location.
Pre	-
Post	The unit moves to the chosen location (or as close as it can get) whilst ignoring any enemy unit along the way (i.e. the unit will not automatically attack anything).

3.3.9 patrol/2

Description	Patrol between a unit's current position and the given location.
Syntax	<code>patrol(<X>, <Y>)</code>
Parameters	<code><X></code> : The x-coordinate of the chosen location. <code><Y></code> : The y-coordinate of the chosen location.
Pre	-
Post	The unit patrols between its current position and the chosen location (or as close as it can get); any enemy unit that it encounters will be chased until it is no longer visible or alive, after which the unit will return to its patrol route.
Note	Terran Medics will heal any friendly units they encounter.

3.3.10 stop/0

Description	Stop performing an action.
Syntax	<code>stop</code>
Pre	The unit is performing some kind of action.
Post	The unit stops performing its current action.

3.4 Workers

The actions in this section can only be executed by worker units.

3.4.1 build/3

Description	Build a building on the given location.
Syntax	<code>build(<Type>,<X>,<Y>)</code>
Parameters	<p><code><Type></code>: The type of building that should be built. See 4.4.</p> <p><code><X></code>: The x-coordinate of the build location</p> <p><code><Y></code>: The y-coordinate of the build location</p>
Pre	The unit is capable of constructing the chosen building and the build location is visible, not obstructed, and fitting for the given building.
Post	The unit goes moves the build location (if needed) and starts constructing the building there. Zerg Drones will morph (i.e., the drone will be lost), Terran SCVs will be busy constructing for a while, and Protoss Probes will instantiate a warp (i.e., the probe does not have to remain at the build location). See also <i>cancel/1</i> and <i>repair/1</i> .

3.4.2 gather/1

Description	Gather a specific resource (minerals or vespene gas building).
Syntax	<code>gather(<Id>)</code>
Parameters	<code><Id></code> : The ID of the chosen resource.
Pre	The given resource is visible and reachable.
Post	The unit starts gathering the chosen resource. It automatically moves back and forth between the resource and the closest resource center.

3.4.3 **repair/1 (Terran only)**

Description	Repair a unit or complete an unfinished building.
Syntax	repair (<Id>)
Parameters	<Id>: The ID of the unit to repair or of the building to complete construction of.
Pre	The unit is a Terran SCV, has the resources to repair, and the target unit is visible (and reachable)
Post	The SCV moves towards the selected unit (if needed) and repairs it or resumes its construction.

Chapter 4

Knowledge

This chapter lists the knowledge predicates that are supplied in a Prolog file with all the example agents in the environment installer. These represent static knowledge about StarCraft that does not change in between matches. For easy reference, this section also includes a list of all unit, tech, and upgrade types per race.

4.1 Predicates

4.1.1 unit/2

Description Indicates all possible unit types.

Syntax `unit(<Name>,<Race>)`

Example `unit('Protoss Reaver',protoss)`

Parameters	<Name>	The full name of the unit type (i.e. as used in actions and percepts).
	Type Range	String See 4.4
	<Race>	The race the unit type belongs to.
	Type Range	String [terran,zerg,protoss]

4.1.2 tech/2

Description Indicates all possible tech types.

Syntax `tech(<Name>,<Race>)`

Example `tech('Tank Siege Mode',terran)`

Parameters	<Name>	The full name of the tech type (i.e. as used in actions and percepts).
	Type Range	String See 4.2
	<Race>	The race the tech type belongs to.
	Type Range	String [terran,zerg,protoss]

4.1.3 upgrade/2

Description Indicates all possible upgrade types.

Syntax `upgrade(<Name>,<Race>)`

Example `upgrade('Ventral Sacs',zerg)`

Parameters	<Name>	The full name of the upgrade type (i.e. as used in actions and percepts).
	Type Range	String See 4.3
	<Race>	The race the upgrade type belongs to.
	Type Range	String [terran,zerg,protoss]

4.1.4 costs/6

Description Information about the costs in resources, time and existing units or technology of a unit, tech, or upgrade type.

Syntax `costs(<Name>,<Minerals>,<Gas>,<SupplyOrEnergy>,<BuildFrames>,<RequiredUnitsOrTech>)`

Example `costs('Zerg Lurker', 50, 100, 4, 600, ['Lurker Aspect','Zerg Hydralisk'])`.

Parameters	<Name> Type Range	The name of the unit, tech, or upgrade type. String See 4.4, 4.2, 4.3
	<Minerals> Type Range	The required amount of minerals to train/research the type. Integer [0–∞]
	<Gas> Type Range	The required amount of gas to train/research the type. Integer [0–∞]
	<SupplyOrEnergy> Type Range	For units: the required (or supplied, represented with a negative number) amount of supply (x2 compared to what is visible in the game). For tech: the required amount of energy to use (as an ability). For upgrades: always 0. Integer [0–∞]
	<BuildFrames> Type Range	The number of game frames that are required to complete training/researching the type. Integer [0–∞]
	<RequiredUnitsOrTech> Type Range	A (possibly empty) list of unit types and/or tech types that are required to be present when starting to train/research the type. List of Strings See 4.4 and 4.2

4.1.5 stats/6

Description Information about the static properties of unit types.
 Syntax `stats(<Name>,<MaxHealth>,<MaxShield>,<MaxEnergy>,<TopSpeed>,<Conditions>)`
 Example `stats('Protoss High Templar', 40, 40, 200, 32, [canMove,organic,usesEnergy])`.

Parameters	<Name> Name Range	The name of the unit. String See 4.4
	<MaxHealth> Type Range	The maximum amount of health for units of the type. Invincible units (like spells) have 0 here. Integer [0–∞]
	<MaxShield> Type Range	The maximum amount of shield for units of the type. Integer [0–∞]
	<MaxEnergy> Type Range	The maximum amount of energy for units of the type. 0 for units that do not use energy at all. Integer [0–∞]
	<TopSpeed> Type Range	The top movement speed for units of the type (without upgrades). Integer [0–∞]
	<Conditions> Type Range	A (possibly empty) list static conditions for units of the type. List of Strings [addon, building, canBurrow, canDetect, canLift, canMove, canTrain, flies, mechanical, organic, requiresCreep, requiresPsi, robotic, spell]

4.1.6 metrics/5

Description Information about the metrics (i.e. on the map) of unit types.

Syntax `metrics(<Name>,<Width>,<Height>,<SightRange>,<SpaceRequired>)`

Example `metrics('Terran Bunker', 3, 2, 10, -4).`

Parameters	<Name> Name Range	The name of the unit. String See 4.4
	<Width> Type Range	The number of build tiles the unit is wide. Integer [0-∞]
	<Height> Type Range	The number of build tile the unit is high. Integer [0-∞]
	<SightRange> Type Range	The number of build tiles the unit's visibility reaches (without upgrades). Integer [0-∞]
	<SpaceRequired> Type Range	The space required to load this unit into a loadable unit if positive; a negative number indicates the space a loadable unit provides for other units (although e.g. Overlords require an upgrade to actually use this space). Integer [-8-8]

4.1.7 combat/6

Description Information about the offensive capabilities of unit types or tech types (i.e abilities used on units or locations). All damages take attack speed into account, but not specific trade-offs (e.g. damage against organic vs. mechanic units). None of the properties take possible upgrades into account.

Syntax `combat(<Name>,<GroundDamage>,<AirDamage>,<CooldownFrames>,<Range>,<SplashRadius>)`

Example `combat('Psionic Storm', 14, 14, 45, 9, 1).`

Parameters	<Name> Name Range	The name of the unit String See 4.4
	<GroundDamage> Type Range	The amount of damage the type does to ground units. 0 means it cannot attack ground. Integer [0-∞]
	<AirDamage> Type Range	The amount of damage the type does to air units. 0 means it cannot attack air. Integer [0-∞]
	<CooldownFrames> Type Range	The number number of game frames the type needs to cool down after an attack (i.e. wait before launching another attack). Integer [0-∞]
	<Range> Type Range	The number of build tiles the type's attack can span. Integer [0-∞]
	<SplashRadius> Type Range	The number of build tiles this type's attack can do splash damage (0 means no splash). Integer [0-∞]

4.2 Tech Types

All tech types that can be researched for each race and used as an ability by the indicated unit.

4.2.1 Terran

Battle Cruisers

Yamato Gun

Command Centers

Scanner Sweep

Ghosts

Lockdown

Personel Cloaking

Nuclear Strike

Marines / Firebats

Stim Packs

Medics

Healing

Restoration

Optical Flare

Science Vessels

Defensive Matrix

EMP Shockwave

Irradiate

Siege Tanks

Tank Siege Mode

Vultures

Spider Mines

Wraith

Cloaking Field

4.2.2 Protoss

Arbiters

Cloaking Field

Recall

Stasis Field

Corsairs

Disruption Web

Dark Archons

Feedback

Maelstrom

Mind Control

Dark Templars

Dark Archon Meld

High Templars

Archon Warp

Psionic Storm

Hallucination

4.2.3 Zerg

Generic

Burrowing

Defilers

Dark Swarm

Plague

Consume

Hydralisks

Lurker Aspect

Lurkers

Burrowing (can be used without having it researched)

Queens

Infestation

Parasite

Ensnare

Spawn Broodlings

4.3 Upgrade Types

All upgrade types that can be researched for each race at the indicated building.

4.3.1 Terran

Academy

U-238 Shells

Caduceus Reactor

Armory

Terran Vehicle Weapons (1,2,3)

Terran Vehicle Plating (1,2,3)

Terran Ship Weapons (1,2,3)

Terran Ship Plating (1,2,3)

Covert Ops

Ocular Implants

Moebius Reactor

Engineering Bay

Terran Infantry Weapons (1,2,3)

Terran Infantry Armor (1,2,3)

Machine Shop

Ion Thrusters

Charon Boosters

Physics Lab

Colossus Reactor

Science Facility

Titan Reactor

Control Tower

Apollo Reactor

4.3.2 Protoss

Arbiter Tribunal

Khaydarin Core

Citadel of Adun

Protoss Plasma Shields

Leg Enhancements

Cybernetics Core

Singularity Charge

Protoss Air Weapons (1,2,3)

Protoss Air Armor (1,2,3)

Fleet Beacon

Apial Sensors

Gravitic Thrusters

Argus Jewel

Carrier Capacity

Forge

Protoss Plasma Shields (1,2,3)

Protoss Ground Armor (1,2,3)

Protoss Ground Weapons (1,2,3)

Observatory

Gravitic Boosters

Sensor Array

Robotics Support Bay

Reaver Capacity

Scarab Damage

Gravitic Drive

Templar Archives

Argus Talisman
Khaydarin Amulet

4.3.3 Zerg

Defiler Mound

Metasynaptic Node

Evolution Chamber

Zerg Melee Attacks (1,2,3)
Zerg Missile Attacks (1,2,3)
Zerg Carapace (1,2,3)

Hydralisk Den

Muscular Augments
Grooved Spines

Lair / Hive

Ventral Sacs
Antennae
Pneumatized Carapace

Queen's Nest

Gamete Meiosis

Spawning Pool

Metabolic Boost
Adrenal Glands

(Greater) Spire

Zerg Flyer Carapace (1,2,3)
Zerg Flyer Attacks (1,2,3)

Ultralisk Cavern

Chitinous Plating

Anabolic Synthesis

4.4 Unit Types

StarCraft's unit types (per race and type).

4.4.1 Terran

Ground

Terran Firebat

Terran Ghost

Terran Goliath

Terran Marine

Terran Medic

Terran SCV

Terran Siege Tank

Terran Vulture

Terran Vulture Spider Mine

Air

Terran Battlecruiser

Terran Dropship

Terran Nuclear Missile

Terran Science Vessel

Terran Valkyrie

Terran Wraith

Buildings

Terran Academy

Terran Armory

Terran Barracks

Terran Bunker

Terran Command Center

Terran Engineering Bay

Terran Factory

Terran Missile Turret

Terran Refinery
Terran Science Facility
Terran Starport
Terran Supply Depot

Addons

Terran Comsat Station
Terran Control Tower
Terran Covert Ops
Terran Machine Shop
Terran Nuclear Silo
Terran Physics Lab

Spells

Spell Scanner Sweep

4.4.2 Protoss

Ground

Protoss Archon
Protoss Dark Archon
Protoss Dark Templar
Protoss Dragoon
Protoss High Templar
Protoss Probe
Protoss Reaver
Protoss Scarab
Protoss Zealot

Air

Protoss Arbiter
Protoss Carrier
Protoss Corsair
Protoss Interceptor
Protoss Observer
Protoss Scout
Protoss Shuttle

Buildings

Protoss Arbiter Tribunal

Protoss Assimilator
Protoss Citadel of Adun
Protoss Cybernetics Core
Protoss Fleet Beacon
Protoss Forge
Protoss Gateway
Protoss Nexus
Protoss Observatory
Protoss Photon Cannon
Protoss Pylon
Protoss Robotics Facility
Protoss Robotics Support Bay
Protoss Shield Battery
Protoss Stargate
Protoss Templar Archives

Spells

Spell Disruption Web

4.4.3 Zerg

Ground

Zerg Broodling
Zerg Defiler
Zerg Drone
Zerg Egg
Zerg Hydralisk
Zerg Larva
Zerg Lurker
Zerg Lurker Egg
Zerg Ultralisk
Zerg Zergling

Air

Zerg Cocoon
Zerg Devourer
Zerg Guardian
Zerg Mutalisk
Zerg Overlord

Zerg Queen

Zerg Scourge

Buildings

Zerg Creep Colony

Zerg Defiler Mound

Zerg Evolution Chamber

Zerg Extractor

Zerg Greater Spire

Zerg Hatchery

Zerg Hive

Zerg Hydralisk Den

Zerg Lair

Zerg Nydus Canal

Zerg Queens Nest

Zerg Spawning Pool

Zerg Spire

Zerg Spore Colony

Zerg Sunken Colony

Zerg Ultralisk Cavern

Spells

Spell Dark Swarm