

Delta Design Game

© Prof. Larry Bucciarelli

Introduction

Delta Design is a team exercise developed at M.I.T. by Prof. Louis Bucciarelli for engineering education at any level - undergraduate, graduate, or professional. Players are assigned one of four roles and form teams to design a new residence suitable for inhabitants of the imaginary Deltoid plane. The design is assembled on a game board by placing triangular red- and blue- colored tiles on a diamond-shaped grid. Each role has its own requirements for the number and placement of tiles, so that the team must make tradeoffs in order to achieve individual and group performance goals within the three or four hours required for learning and playing the game. A brief description of the game and the four roles is presented below.

Life on DeltaP

Life on DeltaP, residential and otherwise, is quite different from what you have grown accustomed to here on Earth. First off, DeltaP is a place, not a planet, so your team will be designing in two-dimensional rather than three-dimensional space. If your design "meets spec" and is considered attractive and functional by your Deltan clients, one view on a single sheet of paper will convey to those responsible for constructing it all the information they need to do so.

The view on this single sheet may not be quite what you expect, however, because in addition to lacking a z-axis, Deltoid space has unfamiliar relations between the x- and y-axes as well. What we think of as "perpendicular" is hopelessly skewed to a Deltan, and vice versa. In our units, a right angle on DeltaP measures 60 degrees or $\pi/3$ radians. Thus all sides of an equilateral triangle form lines considered perpendicular to all others. If there were such a thing as a "circle" on DeltaP, it would be composed of only $4\pi/3$ radians.

But there is no such thing as a "circle" on DeltaP, nor even the concept of continuity embodied therein. In this flat though angular world, residents construct their artifacts strictly with discrete triangular forms. Of these, the equilateral triangle -- with its three perpendicular sides (!) -- is considered the most pleasing. Accordingly, your team will design the residence by assembling into a cluster the most prized building materials on DeltaP, equilateral components called "deltas." Deltas come in red and blue versions and always measure *2 lyns* per side. Four "quarter-deltas," *QDs*, triangular units of area measure with sides of *1 lyn*, fit within a delta.

Lyns? QDs? Believe it or not, the Deltan unit of currency is the Zwig, represented by the! symbol. Not surprisingly, Deltan systems of measurement are as unfamiliar as that for spatial coordinates. All of DeltaP's units of measure share the divisibility and extensibility conventions of the metric system; in the measure of time, for example, there are both microwex and megawex. In relation to the attention- and life-spans of Deltans, these units are roughly equivalent to seconds and years, respectively, here on Earth.

As building components, deltas have functional and aesthetic characteristics that are more complex than their simple form and even dimensions would suggest. Especially when assembled into a cluster, as you will be doing, they behave in interesting ways. Deltas conduct heat among themselves, radiate heat to outer space, melt if too hot, and grow if too cool. Red deltas produce heat. All deltas are subject to DeltaP's two-dimensional gravity (which is itself subject to axial shifts during DeltaP's not-infrequent gravity waves). Three different kinds of cement are needed to join them together, and joint alignment with respect to gravity affects ease of production as well as structural integrity. Different colors and different quantities of deltas cost different amounts of money per delta, and can be assembled in clusters that are either exceedingly ugly or very attractive to the Deltans. Your task will be to create a design that meets prescribed goals for all these characteristics.

Design Team Roles and Responsibilities

Your design team is organized such that each of you will be responsible for a subset of the design goals. Specific instructions for each role will be handed out prior to the game. One of you will be **Project Manager**. Your main concerns will be with cost and schedule, the interpretation and reconciliation of performance specifications, and negotiations with the contractor and client. You want to keep costs and time-to-build at a minimum, but not at the expense of quality. When your team submits its final design, the project manager must report the estimated cost (in zwigs) and the time (in wex) that it will take to build.

Another of you will be the **Structural Engineer**. Your main concern will be to see that the design "holds together" as a physical structure under prescribed loading conditions. You must see to it that the two points at which your structure is tied to ground are appropriately chosen and that continuity of the structure is maintained. When your team submits its final design, the structural engineer must attest to its integrity by identifying the strongest and weakest joints, and estimating the average load on all of the joints expressed as a percentage of the failure load.

Another of you will be the **Thermal Engineer**. You will want to insure that the design meets the "comfort-zone" conditions specified in terms of an average temperature. You must also ensure that the temperature of all individual deltas stays within certain bounds. When your team submits its final design, the thermal engineer must estimate internal temperature and identify the hottest and coldest deltas.

Finally, one of you will be the **Architect**. Your concern is with both the form of the design in and of itself and how it stands in its setting. You must see to it that the interior of the residence takes an appropriate form and that the progress is convenient. You should also develop a design with character. When your team submits its final design, the architect should be prepared to present a sketch and discuss generally how and why the Deltans will find the residence attractive and functional. The architect will also be asked to estimate a few more quantitative measures of architectural performance.

The Design Task

Your Deltan clients have cleared the space shown on the site map and comes to your team with their need for the design of a new residential cluster. The cluster itself must meet the following specifications.

The client wants the cluster to provide a minimum interior area of 100 QDs. The shape of this space, which can of course, exceed the minimum, is a matter of design. The client has expressed enthusiasm for the newer mode of segmenting interior space, a mode that breaks with the two-equal-zone tradition and values the suggested privacy of nooks and crannies. Still the space must be connected, i.e., no interior walls can cut the space into completely separate spaces. There must be one and only one entrance/exit.

The client is known to be color sensitive blue; too much blue brings on the blues, so to speak. No more than 60% blue ought to be allowed; certainly blue deltas are no to exceed 70% of the cluster.

The residence, as all clusters, must be anchored at two points and two points only. There is a limit to the amount of force each anchor can support, as well as to the amount of internal moment each joint can withstand. Exceeding either limit would cause catastrophic failure and send the unwary residents tumbling into the void. The cluster should be designed for a life of thirty megawex. Gravity waves, rare by always possible, should be considered.

The average interior temperature must be kept within the Deltan comfort zone, which lies between 55 and 65 degrees Nin. The temperature of the elements themselves must be kept above the growth point of 20 and below the melt-down point of 85. Delta temperatures outside of this range will result in catastrophic structural failure with little more warning than excessive load.

All of this -- design, fabrication, and construction -- must be done under a fixed budget and within given time period. At your team meeting you are to develop a conceptual design that meets or exceeds all design goals. When each team submits their design, individual members will be asked to report design performance on parameters for which they are responsible.