Quantitative Analysis

The quantitative analysis shows how probabilities and design factors were used for overall game balance. This section will discuss the reasoning of tile distributions, the average length of each game, the time taken per turn, and the ranges of scores.

Tile Distribution

To achieve overall game balance, it was crucial to playtest with various tile designs and their quantities. During our first playthrough of Galactic Realms, we concluded that it was difficult to complete Star Systems with 4-6 sides due to the nature of a hexagonal tile shape. We also ran into situations where it was impossible to complete some features because of the need for different tile types. We adjusted the tile distribution for our second playthrough and added new tile types to deal with the previous problems. These changes included removing all 5-6-sided Star Systems, increasing 1-sided system tiles from 15 to 20 (also adding new variants), decreasing 2-sided system tiles from 21 to 18, and decreasing space-lane-only tiles from 26-20 (also adding new variants).

Of the 80 tiles, our new tile distribution of each category is as follows:

- Military Stations: 7.50%
- Star Lanes: 25.00%
- Star Systems: 67.50%
    - 1-sided: 25.00%
    - 2-sided: 22.50%
    - 3-sided: 18.75%
    - 4-sided: 1.25%

*refer to appendix 1

This emphasis on Star Systems, composing 67.5% of the tiles, reflects their importance as the primary source of points in the game, which is 2 points per completed star system tile, with an additional 2 points if marked with a star. Star Lanes, composing 25.00% of the tiles, give players 1 point per lane. Military Stations, at 7.50% of the tiles, offer 6 points upon completion. Players found that Star Systems are typically harder to complete; therefore, should be worth more points. Whereas the other sources are easier.

Game and Turn Duration

An average turn for a player spans between 0.5 - 1.5 minutes. This depends on the player's tile selection and strategy. The main factor that affects turn length is the tile selection and the different orientations one can place a tile, based on a valid placement. Another factor is strategic thinking of trade-offs. For example, selecting a tile to prevent another from scoring, costs the player a turn to build upon their occupied tiles. A player also has the option to utilize their cosmic token for situational actions, which affects the duration of a player's turn. Therefore for a typical round of four players, it can take 2 - 6 minutes, and with each player having 20 turns this results in a game length of 40 - 120 minutes. Based on our play-testing sessions the game length is within this range.

Probability usage of Cosmic Tokens to reshuffle Tile-Selection Pool

Suppose the player is looking for a specific piece or pieces of which there is a limited quantity in the bag. The table below calculates the probability, at different stages of the game, of finding a specific piece or pieces by using the cosmic token to reshuffle all pieces in the selection area.

Remaining tiles (Game progress)	6 pieces	5 pieces	4 pieces	3 pieces	2 pieces	1 piece
76 (0%)	28.53%	24.27%	19.81%	15.16%	10.32%	5.26%
56 (25%)	37.30%	31.96%	26.29%	20.27%	13.90%	7.14%
36 (50%)	53.48%	46.58%	38.95%	30.53%	21.27%	11.11%
16 (75%)	88.46%	81.87%	72.80%	60.71%	45.00%	25.00%

As one can see, the probability of getting the specific tile you want increases drastically as the game continues. As cosmic tokens are worth 1 point, these are effectively the percentages at which 1 point is worth trading in.

Range of Scores

Given the nature of hexagonal shapes and the finite number of tile permutations, it becomes likely towards the end of the game that players may have exhausted all

opportunities to complete Star Systems, Star Lanes, or Military Stations. Therefore, at the end of the game, players receive one point per uncompleted source, incentivizing players to adopt different strategic approaches near the end-game, focusing on maximizing their score. In practice, end-game scores typically range from 30 to 80 points, reflecting on the various strategies each player adopts.

Appendix 1: Tile Distribution

Tile	Quantity	P(Tile)
mil	2	2.50%
mil-rd-end	2	2.50%
mil-junc	2	2.50%
junc-3	4	5.00%
rd-str	4	5.00%
rd-tight-arc	4	5.00%
rd-tight-arc-dbl	2	2.50%
rd-wide-arc	4	5.00%
rd-wide-arc-dbl	2	2.50%
sys-1	4	5.00%
sys-1-junc-3	2	2.50%
sys-1-rd-end-A	2	2.50%
sys-1-rd-end-B	2	2.50%
sys-1-rd-end-C	2	2.50%
sys-1-rd-str-A	2	2.50%
sys-1-rd-str-B	2	2.50%
sys-1-rd-wide-A	2	2.50%
sys-1-rd-wide-B	2	2.50%
sys-2	2	2.50%
sys-2-rd-end-A	2	2.50%
sys-2-rd-end-B	2	2.50%
sys-2-rd-str	2	2.50%
sys-2-rd-tight-A	2	2.50%
sys-2-rd-tight-B	2	2.50%
sys-2-rd-tight-C	2	2.50%

sys-2-rd-wide-A	2	2.50%
sys-2-rd-wide-B	2	2.50%
sys-3	3	3.75%
sys-3-coa	2	2.50%
sys-3-rd-end	3	3.75%
sys-3-rd-end-coa	2	2.50%
sys-3-rd-wide	3	3.75%
sys-3-rd-wide-coa	2	2.50%
sys-4-coa	1	1.25%
Total	80	
mil Count:	6	7.50%
rd Count:	20	25.00%
sys-1 Count:	20	25.00%
sys-2 Count:	18	22.50%
sys-3 Count:	15	18.75%
sys-4 Count:	1	1.25%
Military Station	7.50%	
Space Lane	25.00%	
Star System	67.50%	