## Mayan Astronomy; Dresden Codex, page 24 (Part 1)

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#### Abstract

Reading articles and papers interpreting the Dresden Codex text and calculations is an exercise that covers the evolution of a broad spectrum of ideas from astrology to observational astronomy. Even today, it is surprising how many inconsistencies can be found in even simple examples that are ignored by scholars in the field.

\section*{Introduction}

Page 24 of the Dresden Codex, Picture 1, is one of the examples of the misconceptions and omissions in publicly available studies. In principle, this page is considered a part of the Venus tables series tracking movements of Venus. In Part 1 of this research note, the focus is on the tables highlighted in blue and referenced as R1, R2, R3 and R4. These are seemingly simple numerical calculations; however, the current interpretation raises some fundamental questions.


Picture 1: Dresden Codex, Page 24, Gates version


To present this analysis in a more understandable way for a contemporary reader who is not used to Mayan symbolism and numerical manipulations, the four tables highlighted in blue were transformed into a present day spreadsheet format as seen in Picture 2.

Picture 2: Page 24, R1, Calculations

| Page 24 R1 |  | 4 |  | 3 |  | 2 |  | 1 |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  | 2880000 | 0 | 0.00 | 0 | 0.00 | 0 | 0.00 | 0 | 0.00 |
|  | 144000 | 0 | 0.00 | 0 | 0.00 | 0 | 0.00 | 0 | 0.00 |
|  | 7200 | 1 | 7,200.00 | 1 | 7,200.00 | 0 | 0.00 | 0 | 0.00 |
|  | 360 | 12 | 4,320.00 | 4 | 1,440.00 | 16 | 5,760.00 | 8 | 2,880.00 |
|  | 20 | 8 | 160.00 | 6 | 120.00 | 4 | 80.00 | 2 | 40.00 |
|  | 1 | 0 | 0.00 | 0 | 0.00 | 0 | 0.00 | 0 | 0.00 |
|  |  |  |  |  |  |  |  |  |  |
|  | Sum |  | 11,680.00 |  | 8,760.00 |  | 5,840.00 |  | 2,920.00 |
|  | Difference |  | 2,920.00 |  | 2,920.00 |  | 2,920.00 |  |  |
|  | 4 |  | 2,920.00 |  | 2,190.00 |  | 1,460.00 |  | 730.00 |
|  | 5 |  | 2,336.00 |  | 1,752.00 |  | 1,168.00 |  | 584.00 |
|  | 8 |  | 1,460.00 |  | 1,095.00 |  | 730.00 |  | 365.00 |
|  | 13 |  | 898.46 |  | 673.85 |  | 449.23 |  | 224.62 |
|  | 20 |  | 584.00 |  | 438.00 |  | 292.00 |  | 146.00 |
|  | 40 |  | 292.00 |  | 219.00 |  | 146.00 |  | 73.00 |
|  | 73 |  | 160.00 |  | 120.00 |  | 80.00 |  | 40.00 |
|  | 104 |  | 112.31 |  | 84.23 |  | 56.15 |  | 28.08 |
|  | 2920 |  | 4.00 |  | 3.00 |  | 2.00 |  | 1.00 |

## Discussion

The table should be read from the bottom right of the table and continue to the top in the right-side portion of the page. In this section there are five distinct tables but only the first four are included in this analysis. Also, in this step the tzolk'in Ahau are not completely included and only the numerical values of these four tables are analyzed.

The starting value in the first column on bottom right is $\mathbf{2 , 9 2 0}$ (table R1). This number is considered to be the result of the synodic period of Venus (584) and orbital period of the Earth ( 365 days) in a simple ration of 5:8. This can be recorded as $5 \times 584=2,920$ days $=8 \times 365$ indicating that indeed we are viewing Venus related data.

Each subsequent column value is a multiple of this number. The last explicit value 35,040 recorded this way is $12^{\text {th }}$ occurrence in the left most column of table R3. The $13^{\text {th }}$ occurrence is $35,040+2920=37,960$ completing the cycle of 104 years if the unit of measure is "day". See Picture 3: Page 24, R2 and R3, Calculations

## Zero Kin

The first observation is related to a consistent row of zeros for "kin" across of all 13 cycles. To my knowledge, this peculiar technique is not addressed in current literature. Most researchers are trying to calculate exact orbital values in days for as many decimal point positions as possible. In reality, over the period of 104 years or 13 cycles of a 2920 days there is an additional number of days added to the 2920 value. It is within the recording ability of the Mayan math system to record these days. However, the
designer of these tables R1 - R3 intentionally decided to keep value 2920 constant and round (truncate) the additional days accumulated during this cycle.

This is a very intriguing action, because it also indicates that there is a disconnect between these values and the tzolk'in date as defined by current convention and an adjustment would be needed especially at the end of the cycle where the error would be greatest. Generally, even when page 24 is considered as a correction page to the Venus cycle, there are no explicit numbers indicating that such a correction was in place. If you go through the effort to define the cycle of a long duration, you probably would include these corrections explicitly and not depend on an assumption that the count will be maintained continuously for an extremely long period of time, and that complex calculations would be remembered.

The conclusion at this point is that tzolk'in was not only used as a calendar, but also as a positional matrix/grid where the numerical value and tzolk'in value as a day would not matter. This aspect will be addressed in more detail in Part 2 of these research notes.

## Recording Errors

There is one particular recording error in these tables that deserves to be analyzed. It is left most column in table R1 highlighted in red (after correction). The original value is recorded as 5 . That should be 8 and it is corrected as such in the spreadsheet table. The error doesn't make a difference in the overall calculation; however, it is a strong indication that the scribe making this copy of the Dresden Codex didn't understand the concept of what he was copying. The complete sequence is consistently incremented in steps of 40 and to a knowledgeable person it would immediately be obvious that value $(5 \times 20)=100$ is not correct and it should be 160 following 120 .

## Uinal Count

While the lowest level entries are zeros, the next level "uinal" entries are a key indication in what steps the data was collected and recorded. It is apparent that the number 40 is one of the key observation factors. Mayans are known to observe the 40-year cycle, but there are no references to a 40 -day cycle, which is a part of the 2920 number. Surprisingly, the second key component in these tables is number 73, which together with 40, creates very interesting combinations. For those who would like to review these sequences, for each table I have added the results of dividing the number in each column by numbers $4,5,8,13,20,40,73,104$ and 2920.

The question of the unit of measure also arises here. Are these tables supporting only days as a unit of measure, or can they track the cycles with the same accuracy when the unit of measure are years or degrees?

## Unit of Measure and counting method

On page 24 there is an apparent technique already observed on page 59 when creating/reading these tables. The rightmost column at the bottom of the R1 table defines the scale 2920 applied as an increment to subsequent columns to the left and up. At the last $12^{\text {th }}$ explicitly recorded occurrence, 2920 is added to complete 13 cycles. The sequence doesn't start with zero as we do today but with a predetermined incremental value, thus it appears that each column value represents the beginning
value to which the increment is added. In this case, the value in column 12 is the beginning of the 13th cycle. This is a very interesting approach to perceive the beginning and end of a cycle.

Picture 3: Page 24, R2 and R3, Calculations (continued)

| Page 24 R2 |  | 4 |  | 3 |  | 2 |  | 1 |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  | 2880000 | 0 | 0.00 | 0 | 0.00 | 0 | 0.00 | 0 | 0.00 |
|  | 144000 | 0 | 0.00 | 0 | 0.00 | 0 | 0.00 | 0 | 0.00 |
|  | 7200 | 3 | 21,600.00 | 2 | 14,400.00 | 2 | 14,400.00 | 2 | 14,400.00 |
|  | 360 | 4 | 1,440.00 | 16 | 5,760.00 | 8 | 2,880.00 | 0 | 0.00 |
|  | 20 | 16 | 320.00 | 14 | 280.00 | 12 | 240.00 | 10 | 200.00 |
|  | 1 | 0 | 0.00 | 0 | 0.00 | 0 | 0.00 | 0 | 0.00 |
|  | Sum |  | 23,360.00 |  | 20,440.00 |  | 17,520.00 |  | 14,600.00 |
|  | Difference |  | 2,920.00 |  | 2,920.00 |  | 2,920.00 |  | 2,920.00 |
|  | 4 |  | 5,840.00 |  | 5,110.00 |  | 4,380.00 |  | 3,650.00 |
|  | 5 |  | 4,672.00 |  | 4,088.00 |  | 3,504.00 |  | 2,920.00 |
|  | 8 |  | 2,920.00 |  | 2,555.00 |  | 2,190.00 |  | 1,825.00 |
|  | 13 |  | 1,796.92 |  | 1,572.31 |  | 1,347.69 |  | 1,123.08 |
|  | 20 |  | 1,168.00 |  | 1,022.00 |  | 876.00 |  | 730.00 |
|  | 40 |  | 584.00 |  | 511.00 |  | 438.00 |  | 365.00 |
|  | 73 |  | 320.00 |  | 280.00 |  | 240.00 |  | 200.00 |
|  | 104 |  | 224.62 |  | 196.54 |  | 168.46 |  | 140.38 |
|  | 2920 |  | 8.00 |  | 7.00 |  | 6.00 |  | 5.00 |
| Page 24 R3 |  | 4 |  | 3 |  | 2 |  | 1 |  |
|  | 2880000 | 0 | 0.00 | 0 | 0.00 | 0 | 0.00 | 0 | 0.00 |
|  | 144000 | 0 | 0.00 | 0 | 0.00 | 0 | 0.00 | 0 | 0.00 |
|  | 7200 | 4 | 28,800.00 | 4 | 28,800.00 | 4 | 28,800.00 | 3 | 21,600.00 |
|  | 360 | 17 | 6,120.00 | 9 | 3,240.00 | 1 | 360.00 | 13 | 4,680.00 |
|  | 20 | 6 | 120.00 | 4 | 80.00 | 2 | 40.00 | 0 | 0.00 |
|  | 1 | 0 | 0.00 | 0 | 0.00 | 0 | 0.00 | 0 | 0.00 |
|  | Sum |  | 35,040.00 |  | 32,120.00 |  | 29,200.00 |  | 26,280.00 |
|  | Difference |  | 2,920.00 |  | 2,920.00 |  | 2,920.00 |  | 2,920.00 |
|  | 4 |  | 8,760.00 |  | 8,030.00 |  | 7,300.00 |  | 6,570.00 |
|  | 5 |  | 7,008.00 |  | 6,424.00 |  | 5,840.00 |  | 5,256.00 |
|  | 8 |  | 4,380.00 |  | 4,015.00 |  | 3,650.00 |  | 3,285.00 |
|  | 13 |  | 2,695.38 |  | 2,470.77 |  | 2,246.15 |  | 2,021.54 |
|  | 20 |  | 1,752.00 |  | 1,606.00 |  | 1,460.00 |  | 1,314.00 |
|  | 40 |  | 876.00 |  | 803.00 |  | 730.00 |  | 657.00 |
|  | 73 |  | 480.00 |  | 440.00 |  | 400.00 |  | 360.00 |
|  | 104 |  | 336.92 |  | 308.85 |  | 280.77 |  | 252.69 |
|  | 2920 |  | 12.00 |  | 11.00 |  | 10.00 |  | 9.00 |

## Conclusion

The ancient Mayan designer accomplished a monumental task creating a cyclical tracking system of four $4 \times 2$ matrices.

Just in the numerical portion of this matrix, the designer was able to define a constant 2920 associated with the Venus and Earth orbital values in days: $2920=365 \times 8=584 \times 5$ as a basic building block of the system. He recognized that this constant can also be expressed as a $73 \times 40$ matrix. Based on this matrix, he created a larger cycle consisting of 13 steps each incremented by a minimal value of 40 units. The resulting cycle is implicitly recorded as $13 \times 73 \times 40=37,960$. Picture 4: Page 24, R4, Calculations, rightmost column.

Because 2920 is based on orbital values, presumably in days, it would not stay constant over a long period of time and additional days would have to be added during the cycle or at the end of the cycle to maintain accuracy with relation to reality. Unless the formula is based on 73 degrees units, there are no explicit instructions how and when to apply such corrections. Instead, each column value recorded in the matrixes R1 - R4 are intentionally rounded (truncated) to the Unial Level of the numerical calculations. That is to say that up to 20 days are potentially lost in each column, if the unit of measure is a day, to maintain this constant.

Picture 4: Page 24, R4, Calculations

| Page 24 R4 |  | 4 |  | 3 |  | 2 |  | 1 |  | Corrected |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  | 2880000 | 0 | 0.00 | 0 | 0.00 | 0 | 0.00 | 0 | 0.00 | 0 | 0.00 |
|  | 144000 | 1 | 144,000.00 | 0 | 0.00 | 0 | 0.00 | 0 | 0.00 | 0 | 0.00 |
|  | 7200 | 5 | 36,000.00 | 9 | 64,800.00 | 4 | 28,800.00 | 1 | 7,200.00 | 5 | 36,000.00 |
|  | 360 | 14 | 5,040.00 | 11 | 3,960.00 | 12 | 4,320.00 | 5 | 1,800.00 | 5 | 1,800.00 |
|  | 20 | 4 | 80.00 | 7 | 140.00 | 8 | 160.00 | 5 | 100.00 | 8 | 160.00 |
|  | 1 | 0 | 0.00 | 0 | 0.00 | 0 | 0.00 | 0 | 0.00 | 0 | 0.00 |
|  |  |  |  |  |  |  |  |  |  |  |  |
|  | Sum |  | 185,120.00 |  | 68,900.00 |  | 33,280.00 |  | 9,100.00 |  | 37,960.00 |
|  | Difference |  | 116,220.00 |  | 35,620.00 |  | 24,180.00 |  | 340.00 |  | 2,920.00 |
|  | 4 |  | 46,280.00 |  | 17,225.00 |  | 8,320.00 |  | 2,275.00 |  | 9,490.00 |
|  | 5 |  | 37,024.00 |  | 13,780.00 |  | 6,656.00 |  | 1,820.00 |  | 7,592.00 |
|  | 8 |  | 23,140.00 |  | 8,612.50 |  | 4,160.00 |  | 1,137.50 |  | 4,745.00 |
|  | 13 |  | 14,240.00 |  | 5,300.00 |  | 2,560.00 |  | 700.00 |  | 2,920.00 |
|  | 20 |  | 9,256.00 |  | 3,445.00 |  | 1,664.00 |  | 455.00 |  | 1,898.00 |
|  | 40 |  | 4,628.00 |  | 1,722.50 |  | 832.00 |  | 227.50 |  | 949.00 |
|  | 73 |  | 2,535.89 |  | 943.84 |  | 455.89 |  | 124.66 |  | 520.00 |
|  | 52 |  | 3,560.00 |  | 1,325.00 |  | 640.00 |  | 175.00 |  | 730.00 |
|  | 65 |  | 2,848.00 |  | 1,060.00 |  | 512.00 |  | 140.00 |  | 584.00 |
|  | 104 |  | 1,780.00 |  | 662.50 |  | 320.00 |  | 87.50 |  | 365.00 |
|  | 260 |  | 712.00 |  | 265.00 |  | 128.00 |  | 35.00 |  | 146.00 |
|  | 2920 |  | 63.40 |  | 23.60 |  | 11.40 |  | 26.76 |  | 13.00 |

While the 13th occurrence of this cycle is not explicitly shown in these tables, calculated values are added by the author at the end of the R4 spreadsheet calculation for illustration purposes. The values in this column have interesting properties. While up to this point the sequence could be defined based on $73 \times 40$ (thirteen and 20 correlation didn't produce integers), this column could also use the $13 \times 20$ correlation and continue to do so in each subsequent column going to the left and $73 \times 40$ is no longer applied.

Thus, we can conclude that these matrices (tables) are tracking at least 3 distinct cycles: Inner loop of 2920 constant, 13 cycles of the 2920 itself and a new cycle which can be correlated to ( $2920 \times 13$ ) by 20 $\times 13$ multiples.

Unanswered questions are:

- Are these tables on page 24 of Dresden Codex designed to track indefinite movements of Venus only, or are they using Venus based orbital values as a unit of measure to track something else?
- Because this is a system based on a cyclical process, could it be that this system is supporting multiple units of measure such as, hours, days, years or degrees?
- Is the Tzolki'in concept of exact dates association really only explanation for the 260-day cycle? The tables R1 - R4 clearly display that rounding (truncation) is applied, thus a unique connection of the dates is no longer maintained and "date" could be substituted with a much broader definition as position marker.

