Air and Space this Week

Item of the Week

"Mars is Hard":

A Mars Mission/Element Spreadsheet

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[KEY WORDS: "Mars" "mission" "element" "batting average"]

The 2020 window for launching to Mars is going on now. Three missions, the subjects of last week's "Item of the Week," are presently on their way. The UAE's orbiter, Hope; the Chinese orbiter/lander/rover combo, Tianwen-1*; and NASA's* Mars 2020 *spacecraft are presently* en route *for an arrival in early 2021.*

Two things have happened the past week that make me want to extend last week's Item topic to this week, too. Instead of focusing on the three missions now underway to Mars, I want to reflect on how difficult Mars exploration has proved to be over the past few decades.

The first thing was the successful launch of the USA's *Mars 2020* mission on July 30, just after I sent out the last installment of A+StW. At this time, all three missions seem to be in good shape. *Mars 2020* did have a minor glitch and went into "safe mode" briefly, but all is OK now. Mission status info:

Hope: https://www.planetary.org/space-missions/uae-hope

Tianwen-1: https://www.planetary.org/space-missions/tianwen-1

Mars 2020: https://mars.nasa.gov/mars2020/timeline/launch/status

The second thing that came up was a conference call I had with my former boss at NASA and NASA's Chief Historian. I was on a detail assignment to NASA HQ in 2012/3, and one of my final projects was to come up with a way of gaging the success/failure of Mars missions up to that time. A lot of different people were working on that issue, but we all had slightly different definitions of "success" and "failure." So when the media wanted to know how successful Mars exploration had been up to the time of the *Curiosity* launch, they didn't always get the same answer, or they got an answer with a lot of qualifying explanation. I'm not a expert in Public Affairs, but even I know better than to tell different stories to a reporter; it's sure to raise their suspicions, in this case, unnecessarily. The three of us had independently realized the importance of revisiting the issue, and once we realized that all three of us were working on "final" numbers, we knew we had to talk.

The outcomes of the more recent missions were well-documented, and solid historical work on the older missions, especially those of the USSR, has been made. The question is, how to fairly and consistently present that information in a meaningful way.

The first thing to note is that "Mars is Hard!" New technologies had to be developed to explore Mars remotely, and any time complex technology is utilized, there are always some "growing pains." Many of the earliest missions failed because the rockets that carried them aloft, or were to take them on to Mars, failed. The spacecraft likely carried problems that would have caused mission failure, but the mission didn't last long enough for those problems to surface. So keeping track of the causes of mission failure is important.

Another problem is that missions to Mars have grown in complexity over the years. To most people, a "mission to Mars" means a spacecraft that is put on a rocket and launched to Mars. But some missions are more complicated than others. It's easy to assess success on an early fly-by mission – the spacecraft either flew by Mars and then returned data to Earth or it didn't. But even that is subject to consideration, for example, what if the spacecraft did fly by Mars successfully, but the data received was much less in quantity/quality than expected. Was that mission a success, or a failure, especially if there is no provision for "partial credit?"

The "partial" issue gets even worse for later missions, those that had more than one mission element. *Mars Express* is a good example: it had an orbiter and a lander. The former was a total success and is still in operation, the latter was an abject failure, crashing on landing. Was that mission a success, or a failure? So we needed a way to be able to assess separate mission elements of a given mission. No mission should be considered a "complete" success if any of its elements failed/underperformed.

That's a lot to keep track of. The value-add that I provided the discussion was the creation of a spreadsheet that would keep track of missions, mission elements, the success/partial success/failure of each, in a way that was convenient to use and to add to as missions progress.

I utilized a "reasonable person" approach to assessment, not wanting to get into an in-depth argument over details not particularly germane to a "batting average"-type analysis.

I am making this spreadsheet available to you; see the link in the Item of the Week and in the Archive of Past Items on the A+StW website (I don't want to attach the file to this e-mail to avoid problems with firewalls).

Here's how the spreadsheet is organized. The missions are listed chronologically. The first column of the spreadsheet tallies the missions. To date, we have launched at Mars now 47 times, counting the three *en route*. The second column gives the assessment of each mission as a whole: success, partial success, or failure. The third column gives the name of each spacecraft, and the fourth column gives the link to the NSSDC entry for that spacecraft. The sixth column gives the country/agency of origin, and the seventh gives the launch date. The eighth column gives the type of each mission or mission element (see definitions in the legend). The ninth column gives the assessment for each mission element, and the failure mode if the element was unsuccessful.

The subsequent columns address five different mission/element types: Fly-by, Orbiter, Lander, Rover, and Mars Moons. Each big column has a total of seven individual columns, the first for the total number of elements of that type, the next three for USA success, failure, or partial;

and the final three for other countries success, failure, or partial. The spreadsheet automatically will increment totals when values are inserted in these columns.

There have been 47 missions launched, but since later mission have more than one element, there are more mission elements than missions.

From these data, one can calculate a "batting average" and see trends in how missions fared over the decades. For example, there have been a total of 22 attempts to land on Mars in the 44 missions now completed or in operation at Mars (it's too soon to assess the three missions now *en route*). The USA made 11 of the 22, succeeding with 8 and failing with 3. So our batting average for landers is (8/11 = .727). All 11 of the other landing attempts failed. Overall, of the 44 missions far enough along to be assessed, there were 17 successes, 9 partial successes, and 18 failures, making the overall mission batting averages to be: Success (17/44 = .386), Partial Success (9/44 = .205), and Failure (18/44 = .409). Yes, I know a lifetime baseball batting average of .386 would be an immediate ticket to Cooperstown, but we can/should do better than that with Mars!

The overall mission batting averages for the USA and Other Countries/Agencies are:

USA: Success (16/22 = .727); Partial Success (1/22 = .046); Failure (5/22 = .227)

Others: Success (1/22 = .046); Partial Success (8/22 = .364); Failure (13/22 = .591)

Mars is Hard, indeed, especially when you are new at it!

Note also the entries in the "failure mode" column. Five of the first six attempts to get to Mars failed because of rocketry. There hasn't been a rocketry failure on a Mars mission for the last two decades.

Some of the assessments are not cut and dried. For example, the *Mars 4* spacecraft was supposed to orbit Mars, but for several reasons it could not, but it did acquire useful data as it flew past Mars. It failed in its primary mission, but it was repurposed as a fly-by, and it did return data, hence, it was adjudged to be partially successful as a mission.

Another issue to consider is what happened to a number of mission elements, failure through no fault of its own; its failure was caused by another mission element. The *Beagle II* "mole" rover is an example. It failed because the lander carrying it crashed, not because of some internal flaw.

There will always be room for argument in assessments of this type, but I hope you find this approach, and the spreadsheet, to be useful!

NOTE: I have had some difficulty with posting the **Mars is Hard spreadsheet**. You can access it from the "Other Stuff" page of the Archive on the A+StW website (http://www.drstevenhwilliams.com/otherstuff. However, I am still working out how to allow access directly, from outside the website.

Last Edited on 12 August 2020