APOLLO SUMMARY SHEET (12/10/15)

The following material provides guidance as to the methods for calculating the true cost of Project Apollo. The explanations build on the sources outlined at the end of the main essay.

Guidance and navigation should sum to $595 million, as on the spreadsheet. Within that figure, $100 million went to MIT for the design of the flight computer. Twenty-seven million dollars went to Raytheon for fabrication of seventy-five computers, at a cost per unit of $360 thousand. We identified 32 command modules and lunar landers that used flight computers and allocated the units as follows: $3 million for flight tests (7 units); $6 million for lunar expeditions (17 units); $3 million for post-lunar (8 units). We assigned the cost of the remaining 43 units ($15 million) to spacecraft development (not technology).

As part of guidance and navigation sum, we traced the amounts spent by the A.C. Sparkplug Company on the inertial guidance platform. We placed the cost of that contract at $235 million. Based on the dates of completion, we assigned $55 million to technology development. That left $180 million for production, possibly more than really needed to fabricate the units. We estimated that NASA needed 32 flight ready units, which produced an average cost of production of $5.6 million. We allocated the units as follows: $39 million for flight tests (7 units), $96 million for lunar expeditions (17 units), and $45 million for post lunar (8 units).

Removing the $27 million and $180 million for guidance and navigation allocated to phase two and beyond from the sum total of $595 million leaves $388 million, which we identified as the phase one technology development cost for guidance and navigation.

Tracking and communications should sum to $912 million plus $179 million for construction of ground facilities, equaling $1,091 million. These numbers are taken from the 1974 authorization report. They are allocated as follows: development $179 million for ground stations plus $293 million for equipment (total $472 million); $145 million for test flights; and $474 million for lunar expeditions

Facilities construction totals $1,631 million ($1,810 million less $179 million for ground stations). This number does not appear on the spreadsheet.

Add Surveyor ($483 million), Gemini ($1,283 million), and the supporting technologies ($244 million) noted in the Anderson letter. We added $8 million for spacecraft technology and $84 million for launch vehicle and propulsion technology, numbers taken from the spreadsheet.

Mission design and analysis totalled $2.2 million.

Engine development should total $980 million, as per the spreadsheet. Stages to Saturn says $900 million. All of that gets assigned to development.

Little Joe II cost $22 million ($21.5 for purposes of calculation) total. We know the marginal production cost of the fifth launch unit: $337 thousand. Working backwards, I doubled the cost for each preceding unit. That produced a total of $5 million ($4.7 million as calculated), estimated as the production cost of the four vehicles used to test Apollo hardware. I subtracted $4.7 million from $21.5 million to establish the development cost (including one development test flight) of the Little Joe II: $17 million. I then checked the percentage of average unit production cost relative to total development cost, comparing the ratio for Little Joe II (7 percent) to the Saturn V (5 percent).

We took the total cost of the Saturn I from *Stages to Saturn*: $838 million. (The spreadsheet says $836 million.) I allocated $440 million to development, $298 million to Apollo flight tests, and $99 million to the Pegasus micrometeoroid satellite. These are estimates, based largely on the dates of expenditure, as I could not find a reliable figure for the recurring unit production cost. Further investigators might look at the Saturn I file at the NASA History Office in DC or in MSFC Huntsville for the latter.

For the Saturn IB, we used the total cost from *Stages to Saturn*: $1,002 million. I assigned $395 million for development and $234 million for Apollo hardware tests. $373 million went for left-overs: Skylab, Apollo-Soyuz, museum and scrap.

The Saturn V should total $6,539 million, again from *Stages to Saturn* ($6605 million is given on the spreadsheet). I listed development at $3,764 million. I accepted the ready-to-launch cost as $185 million, allocated as follows: $555 million for 3 test flights, 9 launches to the Moon for $1,665 million, and 3 vehicles left over (one used for Skylab) for $555 million.

The command and service module should total $3,841 – the single line figure from the spreadsheet which is $3,841 million – plus $920 million from those other four lines for general support (see below). Grand total = $4,761.

Rockwell produced 18 flight-ready units. The first 15 cost $55 million each to produce; three units used for the last three lunar missions (Apollo 15, 16 and 17) cost $65 million each. I assigned four units of the 18 units to pre-expedition test flights (Apollo 4, 6, 7, and 9). Nine units went to the Moon. NASA allocated five to the post-lunar program; four actually flew. (The fifth served as a rescue back-up for the Skylab program.)

Rockwell produced additional units. These are more difficult to count, since some were never finished while others were used in development tests that did not require a fully flight-ready spacecraft. We estimate that Rockwell produced or was

in the process of producing 18 additional units. I assigned one of those units to the flight test program (Apollo/Saturn 202). I estimated that one additional unit was constructed in a flight-ready form but never used for that purpose. Hence the cost of one additional "left over" unit should be assigned to the unused post-lunar category. The remaining 16 units we assigned to development since most were used for the purpose of refining various features of the flight-ready configuration.

So the allocation appears as follows: five units used in full flight tests ($275 million), nine units used for lunar expeditions ($525 million), and six units assigned to the post-lunar phase ($330 million). The residual we assigned to development: $3,631 million.

All of the remaining items listed under spacecraft on the spreadsheet should appear elsewhere or be assigned to the command and lunar modules. These include guidance and navigation (above), spacecraft technology (above), lunar module (below), and overall mission design and analysis ($2 million that appears at the opening to phase 2). In addition, the spreadsheet identifies funds spent on systems engineering ($118 million), supporting development ($145 million), integration and checkout ($222 million), and support ($967 million). The latter four figures total a whopping $1,451 million. I prorated those sums and added them to the development phase for the command and service module ($920 million) and the lander ($531 million).

The lunar module should total $2,407 million, as per the spreadsheet, plus $531 million for those other four items. Grand total = $2,938. The contractor produced 15 units at a recurring cost of $51 million per unit (not $40 million as per Cost of Mission). I allocated $102 million to flight tests (2 units), $408 million to Moon expeditions (8 units), $153 million for units produced for missions never flown (3 units), and $51 million for an end-of-production left over (1 unit) that was scrapped. The 14 units assigned in this fashion cost $714 million. I distributed this sum to flight tests, lunar expeditions, and post-lunar activities. I ascribed the remaining $2,224 million to development, basically by subtracting the recurring costs from the grand total. That placed the remaining unit, which was used in early ground tests, under development. That unit wound up in the National Air & Space Museum.

Don't forget to account for experiments which appear as $126 million on the spreadsheet and $205 million from the Cost of Missions sheet. I used the larger figure.

The figures for flight operations for the Moon program required considerable interpretation. The spreadsheet reports $2,525 million. The 1974 authorization figures suggest that NASA spent $1.7 billion. Note that the authorization committee source also lists $0.9 billion for tracking. I used the lower sum ($1.7 billion) and treated tracking separately. For flight operations, I allocated $940 million for test

flight operations and $760 million for Moon flight operations (the latter taken from cost figures for individual missions).

I allocated the operations budget as follows: test flights and early operations $940 million and lunar expeditions $760 million. As noted earlier, tracking expenses add $145 million for test flights and $474 million for lunar expeditions.

Note that description of the post-lunar phase in the essay does not provide a breakdown by activity – it merely summarizes the total expenditure. The breakdown is easy to construct and consists of the following: 3 Saturn V rockets ($185 million each), 6 command and service modules ($55 million each), and 4 unused lunar modules ($51 million each). Guidance and navigation added $48 million -- essentially the allocated cost of the eight flight computers ($3 million) and eight guidance platforms ($45 million) associated with the spacecraft that flew or could have flown.

The remaining item on the spreadsheet is $58 million for ground systems, mainly mission control. I assumed that this was captured under construction of facilities and thus did not count it separately.

After all was done, we allocated the program management total of $2.5 billion. We concluded that this sum applied to budget lines directly assigned to Project Apollo. Hence we omitted tracking and communication, facilities construction, Surveyor, Gemini, supporting technologies, and $70 million contributed by the U.S. Army to engine development, Little Joe, and Saturn 1. While these sums supported Project Apollo, they were carried on separate budget lines with their own program management allocation. Removing these sums produced an Apollo base as follows: $480 million for phase I, $11,398 million for phase II, $2,451 for phase III, and $3,665 for phase IV. We prorated the $2.5 billion to the four phases based on the Apollo base sums only. Omission of hardware assigned to post-lunar activities like Skylab is a bit misleading, since those outlays were incurred during the production of that material. Nonetheless, we redistributed the program management burden of that share away from Apollo on the grounds that while spent during the Moon race, it paid for activities conducted later. The remaining allocations for program management thus represents the "institutional tax" or overhead expense of operating the three human space flight centers during the Apollo years.

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