

RMS questions of interest – ngEHT – 2020.01.13
Technical/Risk/Cost/Schedule/Management:

This partial response to the recent Astro2020 panel request for information includes material that addresses two questions in advance of the schedule telecon set for Friday, Jan 31. At the telecon, we will update responses to these questions as needed.

Q5* For each of ten new 10m diameter antennas, the envisaged cost is ~ \$6M. What is the Basis of Estimate for this cost?

Response In our RFI response, we estimated the total cost of each 10m dish at \$6.7M (FY2020 dollars), not including digital back ends and the correlator, which were listed as separate line items. We itemize this number below. Total dish cost was the sum of four components:

- Dish itself – We scaled this from the known price of the 12m ALMA prototype antenna, \$5.6M in 2003. With a rough estimate of inflation, we extrapolated to \$8M in 2020. We then scaled to a 10m dish using a diameter-to-2.3 scaling rule of thumb, to give a dish-only cost of \$5M (rounded down).
- Setup on site – Estimated at \$800K as consensus number from collective expertise in EHT collaboration.
- Power – Estimated from vendor quote (May 2019, Solar Saver, Johannesburg) ~450K Euro for 600kWh/24h power service. In our RFI response, we rounded the dollar equivalent to \$600K.
 - The quote included
 - 72 kVA grid forming battery inverter
 - 389 kWh lithium battery system
 - 130 kW solar power system
 - 60 kVA diesel back-up generator, closed, silent, remote start via solar system controller
 - Inverters and batteries in containerized enclosures, insulated, air conditioned
- Maser – We received quote of ~\$300K last summer from T4Science (Neuchâtel, Switzerland) in connection with NSF ngEHT MSRI design project.

Since our original RFI response, we have revised these numbers as follows:

- Using the same inflation rate – 3% – that we assumed in the tables included with our RFI response, the cost of a 12m antenna in 2020 becomes \$9.3M.
- The correct scaling exponent for dish cost should be 2.7 (Meinel, A.B., SAO Special Report 385, pp 9-22, 1979). With this, the scaled cost of a 10m dish in FY20\$ is \$5.7M to the nearest \$100K, an increase of \$700K.
- Using today's dollar/Euro exchange rate (1.1), and inflating 3% from 2019 to 2020, the cost of power should be \$510K, a reduction of ~\$100K.

As a result of these corrections, the FY20\$ cost per dish should be \$7.3M instead of \$6.7M. The total FY20\$ cost for 10 dishes is then \$73M instead of \$67M. The total cost in real-year dollars is \$88.5M instead of \$81.2M.

As stated in our December RFI response, a deliverable of the current Mid-Scale Research Infrastructure (MSRI) design NSF award to the ngEHT is to refine these antenna costs. This will include not only discussion with vendors, but we also anticipate collaborative work with other projects that require new radio dish construction such as the next-generation VLA (ngVLA) and ALMA, which may procure additional submm dishes for array expansion at the Atacama, Chile site. These efforts are aimed at exploring synergies and possible cost efficiencies in development of joint tools and models for new dish design. In the ngVLA case, we expect to continue discussions on costs for new site development, making use of their prior and ongoing studies.

Q6* What is the Basis of Estimate for the operations cost of approximately \$14M/yr, split equally between the U.S. and foreign partners? Does this value assume that the ngEHT consortium will fully fund the operation of each of the new 10m telescopes, or is it assumed that partnering “local institutions” will partly fund the operation of these telescopes? What (if anything) would the new telescopes be used for when not participating in ngEHT observing sessions?

Response The ngEHT operations model is in development. For that reason, we based our estimate on very rough extrapolation from today’s costs, with limited nuance. We estimated the operations cost of \$10M (FY2020 dollars) in our RFI response by extrapolating from the cost of operating today’s EHT, which is ~\$4M/yr. This covers staffing at sites that already exist (were not built expressly for EHT), plus time on the correlator and time of observers from EHT Collaboration institutions. It also assumes the present operational cadence (two weeks of dress rehearsal and two weeks of observation per year). This was doubled to \$8M to account for doubling the number of dishes. We then rounded up to an even \$10M as proxy for the underlying additional costs of maintaining new sites – which *would* be built expressly for ngEHT – in operable condition. Accounting for inflation, this results in the \$14M/year total estimated real-year cost for operations in out-years. In our RFI response, we did not consider whether partner institutions would partly fund operations, aside from assuming a 50/50 US/foreign split.

There are at least three ways that these operations costs might be reduced.

- We will, over the coming three years of the MSRI award, actively explore the possibility of sharing use of the ngEHT dishes with local institutions, and we may expect some operational funding support based on that, but at present we feel it is premature to rely on this as a cost-reduction factor. It is not currently factored in.
- The basis for operational cost estimates assumes the current model wherein EHT observers travel to EHT sites to carry out observations. We are in the process of

transitioning to a more centrally based model that relies on increasingly capable monitor & control software, which will allow eventual remote observation with limited local support. It is assumed that over the next several years, this capability will become more routine and that we will be able to more accurately estimate future ngEHT operations costs.

- Since our December RFI response, we have initiated discussions with the ngVLA project on possible co-location of ngEHT/ngVLA dishes for shared infrastructure. Joint work on site development, data transfer and maintenance would be potential areas of cost savings for both projects. These discussions are in early stages, but show promise for eventual impact for at least some ngEHT expansion sites.