Decadal dreams

The 2020 US Decadal Survey for Astrophysics is almost here — but in these years of flat cash and major mission delays, how much can we afford to dream?

The US National Academy of Science's Decadal Survey for Astronomy and Astrophysics is the mechanism through which the US-based astronomical community makes recommendations to NASA on the astrophysics priorities for the upcoming decade (NASA's Planetary Science Division has its own, separate, recommendation process). NASA then uses this ranked wish-list as a basis for its annual budget request to Congress, which decides how to allocate funds. Of course, this is a decision as political as it is scientific, as has been recently evident in the current US President's suggested budget veto of the Wide Field Infrared Survey Telescope (WFIRST) mission — the top priority of the 2010 Decadal process — and NASA's Education Office.

This consultation process is intimately connected with NASA's mission portfolio, and historically has led to the construction of the space-based Great Observatories (Hubble, Compton, Chandra, Spitzer) and, most recently, the James Webb Space Telescope (JWST), the top priority identified in the 2001 Decadal Survey. Following the launch of JWST (currently slated for 30 March 2021), WFIRST will be the next in line for a mid-2020s launch and will focus on understanding dark matter and dark energy using its unique surveying capabilities. WFIRST just passed a series of critical reviews and officially entered its preliminary design phase in May 2018.

The community is now busy preparing the upcoming Decadal Survey, due to be submitted to NASA at the end of 2020. Four mission concepts are in the running for the next Great Observatory: the Habitable Exoplanet Observatory (HabEx), the Large Optical/UV/IR Surveyor (LUVOIR), the Lynx X-ray Observatory (Lynx) and the Origins Space Telescope (OST). One of these missions will be selected for construction during the late 2020s and eventual launch in the mid-2030s. This issue of *Nature Astronomy* features summaries of these mission concepts from the teams behind their development.

The Decadal Survey consultations undoubtedly result in great science: they are by construction ambitious and forward-thinking, and they coordinate group efforts that would otherwise be dispersed into shorter-scale, and thus less impactful, projects. NASA's flagship missions have performed admirably and surpassed the science returns they were commissioned for, with many additional unexpected and serendipitous discoveries. But by the nature of their ambition, these projects are becoming increasingly expensive, and there is a pressing concern (already expressed in the 2001 Decadal) that a large percentage of a limited pool of money is tied to a single major project, leading to an intricate balancing act (as discussed in a comment by Adam Burrows in our July 2017 issue). Cost overruns or failure of such a flagship project would lead to considerable scientific and capital loss. For instance, the cost overrun of billions of dollars for the JWST is well documented, and this year has had the knock-on effect of there being funding cuts for the WFIRST mission and the imposition of a cost cap on the 2020 Decadal mission concepts. The Science and Technology Definition teams behind the four 2020 Decadal concepts have now been asked to prepare a second, much lower-cost, architecture as a contingency in response to the cost cap. LUVOIR's mirror, in its revised design, will have a mirror a quarter of the previous collecting area (around 8 m diameter, only about 20 per cent larger than JWST). This, at least, will free LUVOIR from its constraint of having to be launched in the yet-to-be-developed Space Launch System launch vector. OST, too, will focus on a reduced-cost option, shrinking its mirror from around 9 m to about 6 m in diameter.

This move not only risks delay but also limits ambition, and could reflect badly on NASA. The continued set-backs and cost overruns for JWST risk that the public — or Congress — starts to think that astronomers are 'foolhardy', or more concerningly that astrophysics is 'expensive' or 'expendable' when compared to other potential funding outlets. The recent independent review of JWST's construction progress also identified embarrassing 'human errors' and 'excessive optimism' amongst the reasons behind the two-and-a-half-year delay. A loss of public confidence in NASA (which is the public face of the mission, despite many of the failings being due to the spacecraft hardware contractor, Northrop Grumman) would be disheartening. Congress have been staunch supporters of NASA astrophysics missions and public education, overturning recent Administrations' vetoing of funding for various NASA plans, including WFIRST and its Education Office. However, the recent push-back of the JWST launch to 2021 and the inevitable breach of the cost cap of US$8 billion dollars has left Congress people grumbling.

WFIRST, due for launch in 2025 and with a budget of US$3.2 billion, at least should recover some of the lost ground. Much of the optical system of the telescope has been 'gifted' by another US government department, and it makes use of a much simpler design than JWST that does not include a suite of deployable elements. A US$3 billion budget is realistically the kind of figure that the 2020 Decadal missions will now have to work with, despite the mission concept teams also being urged to consider their original, more costly ideas in parallel. It seems challenging to meet the demands of Paul Hertz, Director of NASA's Astrophysics Division, who recently encouraged the teams to "set bold and ambitious goals for astronomy and astrophysics" and "push the limits of human ambition" in this challenging financial environment. But we must bear in mind that HST's construction cost was not too dissimilar, if adjusted for inflation: US$2.9 billion in 2018 terms; and HST will be celebrating 30 years of top-class science in 2020 — excellent bang for the buck, although we must also consider that higher-hanging fruit are by definition more difficult (read more costly) to reach.

The community is not only looking forward to, but in fact is expecting a similar success for JWST and WFIRST as for HST. It is clear that the difficult journey of JWST from conception to actual launch needs to have its 'happily ever after' if we hope to see any of the concept missions discussed in our issue fly in the 2030s. Given flat budgets and cost caps, the community is now called to work hard to make sure that the successor of JWST and WFIRST — be it HabEx, LUVOIR, Lynx or OST — will convince a cautious funding body and a sceptical public of its feasibility while delivering the same level of science and thrill as its predecessors. ❐

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