Funding Guest Observers on the James Webb Space Telescope

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1 Background

The James Webb Space Telescope (JWST) is the successor to the Hubble Space Telescope (HST). It will be launched in late 2018 with a planned lifetime of five years, but with the goal of operating the observatory for ten years. It will have $10 - 100\times$ the sensitivity of the Hubble Space Telescope at $1.5 - 2.2\mu$m, and $10 - 100\times$ the sensitivity and $10\times$ the resolution of Spitzer at $3 - 28\mu$m. The observatory will be stationed at the Sun-Earth Lagrangian Point (L_2), some 1.5 million kilometers from earth, where it will maintain the same relative position with respect to the Sun and Earth so can be passively cooled to about 40K with a sun-shield. Because of its considerable distance from Earth, the observatory is not designed to be serviceable. Canada is contributing to the JWST mission by building the telescope's guider (the Fine Guidance Sensor, FGS) and by providing the observatory with the Near-InfraRed Imager and Slitless Spectrograph (NIRISS), one of the telescope's four science instruments. Canada's contribution to the JWST is the largest space science investment our country has ever made.

2 Considerations for funding guest observers on the JWST

2.1 Time Allocation Model

It is common practice in astrophysics to grant guest observers on ground-based and space-based astronomical facilities a period of proprietary/exclusive access to data before making it publicly available. This basic model will be retained for the James Webb Space Telescope. Making effective use of this period of exclusive access is clearly integral to the effective exploitation of the time on the telescope won competitively (via peer review).

The most common period for exclusive access to ground-based astronomical data is between 12 months and 18 months. (In the Canadian context: CFHT has a proprietary period of 13 months, and Gemini has a proprietary period of 18 months). The period of exclusive access for guest observers on the Hubble Space Telescope is 12 months. However, in a limited-life mission, such as JWST with its 5-year required life, the interplay between a long proprietary time and short mission lifetime can seriously lessen the astronomy community's ability to build new proposals from data taken during the mission. The situation is illustrated graphically in Figure 1, and is described in a recent letter from

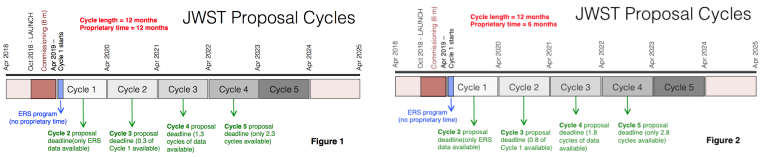

Figure 1: Graphical time line of JWST proposal cycles with proposal deadlines indicated and available data assuming a 12 month proprietary period (left) and six month proprietary period (right). We assume the existence of an Early Release Science campaign (where data on a few fields will be made public immediately to familiarize the community with JWST) in Cycle 1 and also a 0.2 cycle data processing/evaluation period before proposal submission in both cases. In a five year, five-cycle mission, with a 12-month proprietary period (left time line), Cycle 4 is the first cycle able to use all Cycle 1 data to do follow-up. A 6-month proprietary time period substantially increases the amount of data available for proposers (bottom time line), Cycle 2 presents special challenges, because of a lack of availability of access to data from Cycle 1 GO programs on a time that is useful to inform the preparation of proposals in time for the application deadline. The JSTAC therefore recommended that STScI implement a proprietary/exclusive access period for GOs for JWST that is 6 months throughout its life, modified just for Cycle 1 to a default of 0 months, with the option for proposers to request up to 6 months, so as to ensure that some data is available quickly from Cycle 1 programs for Cycle 2 proposers. Figures and explanatory text taken from JSTAC's letter of March 27, 2014.

the James Webb Space Telescope Science Advisory Committee (JSTAC) to the director of the Space Telescope Science Institute (STScI):

> *The JSTAC in May 2013 was again impressed by the impact on scientific productivity that would occur with a 12-month proprietary period. In a 5 year, 5-cycle mission, with a 12-month proprietary period, Cycle 4 is the first cycle able to use all Cycle 1 data to do follow-up. At the Cycle 3 proposal deadline only a small portion of the Cycle 1 data would be available. Based on the chart developed for JSTAC's June 21 2010 letter this fraction was only 1/3rd of the Cycle 1 data. By the final (Cycle 5) proposal deadline only data from a little more than the first two full cycles taken by JWST would be available to the community for follow-up. The limited data availability for proposers is obviously a very undesirable situation and is clearly a serious concern for the overall science return from the mission.*

The pressure on community access will only by heightened by the very high demand (which is typically around 10:1 for the Hubble Space Telescope). On the basis of these considerations, it appears highly likely that JWST will have a proprietary/exclusive access period for Guest Observers of six months. The Canadian community should plan on this basis, and assess the implications accordingly.

2.2 Funding Model

2.2.1 Special challenges

JWST will have the sensitivity needed to undertake transformative observations using small allocations of time. For example, in the near-infrared, imaging depths comparable to the Hubble Ultra-Deep Field

will be achieved in only a few hours of on-source integration. The period in which JWST is active may well be remembered as a once in a lifetime (and certainly once in a generation) 'happy hunting ground' for guest observers. But considerable challenges will need to be overcome if Canadian guest observers are to be able to fully capitalize on the CSA's investment in the facility.

The most general challenge might be characterized as 'complexity', though it is more useful to view it more positively as 'high information density', since it is definitely a feature and not a bug. JWST far surpasses Hubble in terms of the number of available instrument modes. The latter is essentially an imager with limited capability for spectroscopy. In contrast, the JWST will have both a multi-object and an integral field spectrometer, a slitless spectrometer, a non-redundant pupil mask, and two coronagraphs, in addition to three imagers. Rising to the challenge of dealing with the complexity/information richness of JWST without gathering years of experience beforehand (the usual situation with new ground-based facilities), and exploiting JWST to deliver maximum science in only five years, will require careful planning. The project must develop new software tools to support all the modes from the outset, and disseminate them to community and educate them in their use. Most importantly, the partner countries must make available the human resources needed to handle the data flow. The latter piece is perhaps the greatest challenge in the Canadian context, but it is something we need to address, because to a greater or lesser extent our colleagues in JWST partner countries have already done so.

2.2.2 Required funding level

In the United States, allocations of time on the Hubble Space Telescope are accompanied by grants to guest observers whose purpose is to help researchers achieve the scientific objectives laid out in the proposals. ESA investigators do not receive such funding. In general, European guest observers on Hubble are supported by rolling grants to institutions given by national funding agencies, supplemented by funding from EU sources (which are made to individual researchers in some cases, and to specific projects in others). A large fraction of European funding (e.g. rolling grants to institutions) can be reallocated dynamically (and internally) as needed to meet demand, so it is difficult to track the total funding level that the European community devotes specifically to funding researchers who have won time on the Hubble Space Telescope. Therefore we will focus our analysis of the anticipated need for JWST guest observer funding by looking most closely at US funding levels.[1]

In the United States, in the most recent cycle, US$28.6M dollars was allocated by NASA to guest investigators on the Hubble Space Telescope. Recent HST proposals have received around $5000 per orbit for programs of 10 orbits or more; smaller programs tend to get more per orbit, since resources tend to plateau at the 4-6 month work level. Because of the greater complexity associated with JWST, the increased number of on-target hours available per year ($\sim$ 8800 hours for JWST versus $\sim$ 5200 for HST) and the shorter mission lifetime, it is anticipated by NASA that the guest investigator funding level needed for JWST will be larger than for HST. The amount needed has yet to be determined, but scaling from HST the funding level would likely fall in the range US$40M to US$60M.

US-based investigators will have 80% of the time on the telescope, and the Canadian share of JWST is 5%, so as a crude first approximation of the required Canadian funding one can simply normalize the baseline Canadian funding at around 6.25% of the US level. This corresponds to the Canadian share relative to the US fraction of the observing time (i.e. 5/80 of the total). Under this assumption, the corresponding funding levels are:

[1] Of course, it must be recognized at the outset that the research environment in the United States is rather different from that in Canada; we will have more to say about this later, after laying out some basic numbers.

- US$1.78M/year adopting the current NASA HST funding level.
- US$2.5M/year adopting the low end of the anticipated NASA JWST funding level.
- US$3.75M/year adopting the high end of the anticipated NASA JWST funding level.

These numbers do not map directly onto Canadian needs (for example, overheads are higher in the United States). But they do give a sense for the approximate funding required (which is only of order 3% of the capital investment in JWST, and spread out over a number of years) to support JWST guest observations in Canada at a similar level to that in the United States.

It is interesting to compare the funding levels given above with the operating cost of Canada's front-rank ground-based facility, the Gemini Observatory. Canada's 5% share of JWST corresponds to 435h/year, which is roughly the time expected from 54 eight hour Gemini nights. Canada's 18.65% share of the Gemini Observatory corresponds to roughly 45 nights of dark time per Gemini telescope. Assuming only 80% of this time is usable (due to weather losses and other factors), this corresponds to 36 dark nights per telescope. Canadian on-target time with JWST will therefore be about 75% of the Canadian on-target dark time with *both* Gemini telescopes. Canada's contribution to the operation of the Gemini Observatory is $5.5M/year. Our aim in pointing this out is not to try to make the case to the MTR Committee that Gemini is a bad value (we actually think it is a good value), but rather to make the point that for a fraction of our current annual investment in Gemini (a long-lifetime facility) we can ensure that guest observers of JWST (a short-lifetime facility) are funded at levels comparable to that of our peers in JWST partner countries[2]. This will be essential because of the highly competitive landscape in which Canadian guest observers of JWST will operate.

2.2.3 Timing of required funding

Figure 2 illustrates the anticipated sequence of key events in the JWST grant funding process. Cycle 1 is anomalous because the six month gap from launch to the start of the cycle (which includes the time required for orbit insertion and commissioning) will allow ample time for the TAC to meet and funds to be disbursed before the start of Cycle 1. It is more instructive to consider the process beginning with the call for proposals for Cycle 2. Most notable is the fact that the TAC will meet about 3 months before the beginning of the cycle, with successful proposers submitting a budget proposal about a month later, and a preliminary budget being allocated by the funding committee almost at the very start of the cycle. This cadence is what will likely be needed if the average proposer (who gets data six months into the cycle) is to have funding in time to hire a trained postdoc to assist in the data flow before the period of exclusive access to JWST data has expired.

Clearly the funding timescale just described poses severe challenges to the Canadian community. In the past the Canadian Space Agency has funded participation in targeted priority missions through slower mechanisms, such as the *Space Science Enhancement Program* (SSEP). Funding from the SSEP program proved critical to successful Canadian engagement in, for example, Herschel, and Planck. However, funds from the SSEP did not flow quickly (we refer the reader to the reports from the JCSA for details) and it seems likely that funding guest observer time allocations on JWST will require more agile funding mechanisms be put into place. On the other hand, the SSEP (or similar programs) would serve to fund Canadian teams accessing JWST through Guaranteed Time Observations (GTO), since

[2]The comparison presented here suggests that CSA's operational support of NIRISS/FGS at STScI with only four funded FTEs is a very good value. However, examination of operational funding of NIRISS/FGS in detail is beyond the scope of this white paper.

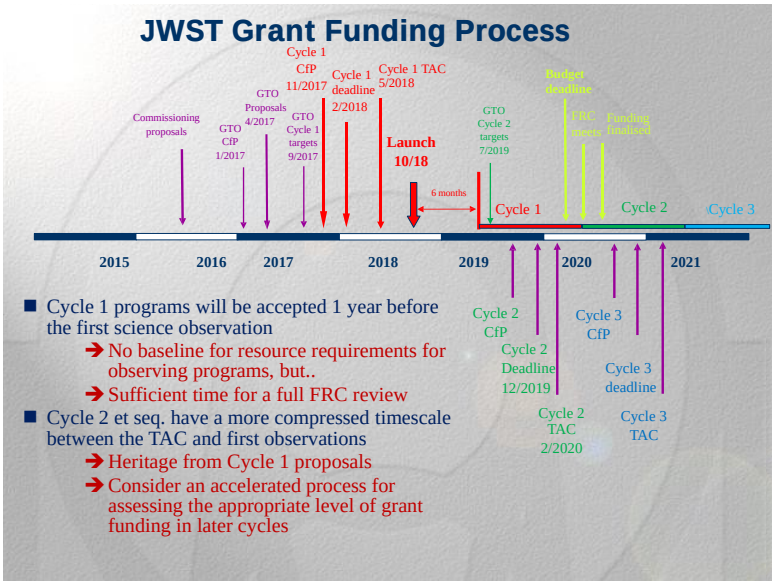

Figure 2: STScI's provisional timeline for JWST funding. Arrows in yellow correspond to funding milestones for Cycle 2. In this model the PI is made aware of the funding level about 3 months after the time allocation committee meeting.

these will be scheduled well over a year in advance of observations. Note that the 450 hours of GTO time corresponds quite closely to one year's worth of Canadian guest observer observations (437h).

2.2.4 Other considerations

Recommendation Six of LRP2010 states that: "Completing and launching JWST is the top priority for Canadian space astronomy.". Furthermore, in Recommendation 34, the LRP2010 report states:

> *The LRPP recommends that CSA set aside funds in the SSEP program to provide support for 4 PDFs in support of JWST and other CSA supported missions. This investment will help ensure that the exceptional data expected from these missions will be utilized to their full extent.*

As noted above, we do not think the SSEP program (or its equivalent) is the right funding vehicle for Guest Observer funding of JWST in Canada (though it might well be the correct vehicle for Guaranteed Time Observer funding). On the other hand, we think it is an excellent idea to assume that the most effective use of Guest Observer funding is to associate it with the hiring of PDFs, since these are so difficult to fund through alternative means (such as NSERC Discovery Grants). The question is, would the number recommended by the LRP2010 adequately support the requirements of Canadian guest observers on the JWST? Another way of looking at this is to ask the following question: what would it take to ensure every JWST guest observer with a permanent job in Canada could afford to hire a postdoc to help with the data flow? Without a detailed demographic study we cannot properly answer

this, although we can attempt a rough estimate that might inform a more detailed analysis by the MTR committee.

An important unknown variable in any assessment of the number of PDFs needed to assist with JWST data analysis is the uncertain mix of small/medium/large programs over which these postdocs would be distributed. If recent Hubble Space Telescope cycles are taken as a guide, around 50% of the time will be on small/regular programs (< 35 HST orbits), 25% on medium programs (35-74 HST orbits), and 25% on large programs (> 74 HST orbits). However, the mix depends heavily on programmatic considerations (i.e. in the case of Hubble, the mix has evolved with time to emphasize larger programs, as STScI has sought to maximize the scientific legacy of the telescope as it nears the end of its life). Absent programmatic inducements (such as setting aside a fixed fraction of time for large programs), time allocation committees tend to favour smaller programs in reaction to finite resources, so it seems likely that in the early years of JWST smaller programs will be emphasized. A better guide to the JWST program size mix might therefore be obtained from considerations of the Gemini queue, in which small programs abound. At present around 30 Canadian-led programs are in typically in Gemini Scientific Ranking Bands 1 and 2 (counting both telescopes) in any given six-month semester, perhaps 2/3 of which actually get completed, corresponding to around 40 per year. Scaling for the relative amount of time available on JWST, we think something like 20–30 Canadian-led JWST programs might be undertaken in any given year-long cycle. Splitting the difference and assuming around 25 programs, and that postdocs are hired with three-year positions (the industry norm) this corresponds to a steady-state rate of adding of about eight PDFs per year into the system, and a steady-state cost to CSA of around $1.875M/year assuming $75K/postdoc/year and a steady state total of 24 postdocs working on JWST activity at any given time. If this were naively divided by the number of hours available (certainly not what we would recommend, but a useful calibration nonetheless) then this would correspond to only $4.3K per hour of JWST time awarded. In the US context this number seems on the low side, but in the US system funding to supplement HST money can be nearly impossible for researchers to obtain, since the reach of NSF personal grants has nothing like the reach of NSERC Discovery Grants (which support $> 50\%$ of active researchers in Canada). Given the broader coverage of funding in Canada, in our opinion JWST support from the CSA should be viewed as supplementary to funds obtained through other other agencies. Therefore the main purpose of CSA's guest observer funding would be to allow active researchers with an NSERC Discovery Grant to hire an otherwise unaffordable PDF. Given the clearly defined purpose of the proposed funding, we recommend that the program be funded and operated as a partnership with CSA and NSERC.

3 Recommendation to the MTR Committee

We recommend that the Canadian Space Agency partner with NSERC to create a program that associates funding with the allocation of time on the James Webb Space Telescope. The main purpose of the proposed CSA/NSERC program would be to allow guest observers to supplement existing grants in order to hire PDFs to assist in the timely reduction, analysis and publication of data from the telescope.