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Science Leadership Opportunities for SKA1 Key Science Projects: A Canadian Case Study

Kristine Spekkens[1,2]

[1] *Royal Military College of Canada*
[2] *Canadian SKA Science Director*

ABSTRACT

This memo estimates science leadership opportunities for SKA1 Key Science Projects (KSPs) over a decade of full operations, focussing on possibilities for a 6% participation level typically discussed in the Canadian context. Starting from assumptions regarding SKA1 operations, the distribution of KSP durations and their management structure, the total number of available leadership positions (KSP leads, executive members, working group leads, and team members) across the project is estimated. Further introducing the concept of SKA1 science leadership "currency", three different science leadership scenarios for a 6% participation in SKA1 are explored: a Proportional scenario where leadership is directly proportional to the participation level, a Top-Heavy scenario where more currency is spent on KSP leads, and a Bottom-Heavy scenario where more currency is spent on team membership. These scenarios produce different distributions of leadership opportunities, with the number of KSP leads varying by a factor of four and the other roles varying by a factor of ∼two between them. Science leadership currency is a potentially useful construct for enabling scientific return on SKA1 investment that is tailored to the interests and expertise of participating countries. If a currency is adopted, its valuation will be an important factor for the IGO Council to consider because it may influence the range of KSPs ultimately undertaken. While the primary goal of this memo is to inform the Canadian astronomical community as part of its 2020 Long Range Plan prioritization process, it is hoped that the methodology and outcomes are also useful to other SKA stakeholders.

1. INTRODUCTION

Canada has a long history of participation in the SKA initiative; it is currently a member of the SKA Organisation (SKAO) and has Observer status on the Council Preparatory Task Force (CPTF). Funding priorities for Canadian astronomy are determined by the Canadian Astronomical Society (CASCA) each decade via the Long

Range Plan (LRP)[1], wherein the SKA has been identified as a top priority for the last twenty years. LRP2020[2] is underway now, and the process of assessing future Canadian ambitions for participation in the SKA project has begun.

SKA1 will be a superb survey instrument, and it is anticipated that most of the available observing time will be allocated to the completion of Key Science Projects (KSPs). While scientific merit will play a central role in determining the KSPs that will be undertaken, scientific return on investment by participating countries will also be taken into consideration. As such, an important consideration for the Canadian astronomical community is the potential for scientific leadership in the KSPs ultimately undertaken given the expected Canadian participation level. While the SKA1 Operations Plans will ultimately be defined[3] by the intergovernmental organisation (IGO) that will oversee construction and operations, estimates of scientific leadership opportunities for a $\sim$6% participation level in SKA1 that is typically discussed in the Canadian community will provide valuable input for LRP2020. This memo provides such estimates[4].

The structure of this document is as follows. In §2 the methodology and assumptions that underlie the scientific leadership estimates are explained, including SKA1 operations, KSP durations and management structure, and the valuation of a scientific leadership "currency" for KSPs. The resulting estimates for a 6% participation level given different expenditures of that currency are presented in §3, which represents a case study for different scenarios of potential interest to the Canadian astronomical community. §4 summarizes the results and discusses the concept of a scientific leadership currency more broadly.

This memo makes implicit and explicit assumptions regarding telescope operations, time allocation and KSP project structure that have not yet been determined for SKA1 and that fall within the purview of the IGO. While the hope is that these assumptions are sensible and ultimately useful, they are not final in concept or value.

2. METHODOLOGY AND ASSUMPTIONS

The set of assumptions that underlie the science leadership estimates are given in Table 1, and divide into observing and KSP distribution assumptions, KSP management structure assumptions, and scientific leadership currency assumptions. Each one is discussed in turn below.

- **Observing and KSP Distribution:** It is assumed that the overall observing efficiency of SKA1-Low and SKA1-Mid (ie. the fraction of the total time in a year spent carrying out science observations) will be 90%. This efficiency is

[1] CASCA LRP website: https://casca.ca/?page_id=75
[2] LRP2020 website: https://casca.ca/?page_id=11499
[3] The SKA1 Operations Plan is a Tier 3 IGO document.
[4] Only KSP leadership opportunities, and not smaller PI project opportunities, are considered here. It is assumed that scientific return on investment will be straightforward to calculate for PI projects since the number of proposals accepted in a given cycle will be large and since many operational precedents for this model exist.

Table 1. Parameter Assumptions

Parameter	Value
Observing and KSP Distribution Assumptions	
Observing Efficiency	90%
Fraction of time spent on KSPs	70%
Commensality Factor	2
Number of large (10,000 hr) KSPs per year	1
Number of medium (5,000 hr) KSPs per year	2
KSP Management Structure Assumptions	
Number of leads, medium KSP	2
Number of executive members, medium KSP	5
Number of working group (WG) leads, medium KSP	10
Number of team members, medium KSP	100
Factor by which to scale from medium to small KSPs	0.5
Factor by which to scale from medium to large KSPs	1.5
Scientific Leadership Currency Assumptions	
Leadership value, medium and large KSPs	1
Leadership value, small KSP	1/2
Value of exec membership relative to leadership for a KSP	2/5
Value of WG membership relative to leadership for a KSP	1/5
Value of team membership	1/50

NOTE—See §2 for details.

similar to that for existing large radio observatories such as the VLA but may be optimistic for SKA1, particularly during early operations. In line with initial operations planning within SKAO, it is assumed that 70% of all observing time will be spent on KSPs and that a factor of 2 in observing efficiency will be gained from commensal observations. This focus on surveys at from onset of full operations differentiates SKA1 from facilities such as ALMA, where most of the observing time is spent on PI science. Commensurate with the fiducial survey sizes being discussed within SKA Science Working Groups, "small" 1,000-hour KSPs, "medium" 5,000-hour KSPs, and "large" 10,000-hour KSPs are considered. It is assumed that an average of 1 large KSP and 2 medium KSPs will be carried out each year, and that the remainder of the KSPs undertaken will be small. These assumptions imply that in a decade of full SKA1 observations a total of 10 large KSPs, 20 medium KSPs, and 21 small KSPs will be undertaken. The high number of medium and large KSPs relative to small ones reflects an implicit assumption made here that producing transformational SKA1 science will require relatively large amounts of SKA1 time. This seems reasonable given that pathfinder instruments will have already completed surveys of several thousands of hours by the time the KSPs get underway, and

Table 2. Case Study Scenarios

Scenario	Currency		Expenditure	
	Lead	**Exec**	**WG**	**Team**
Proportional	25%	25%	25%	25%
Top-Heavy	50%	15%	15%	20%
Bottom-Heavy	10%	25%	25%	40%

Note—Currency valuation is in Table 1 and explained in §2.

is also commensurate with the survey strategies identified by the SKA Science Working Groups (SWGs) to accomplish the High-Priority Science Objectives that are representative of the science that the KSPs will carry out[5]. Indeed, the management structure within the pathfinder survey science teams informs that adopted for KSPs below.

- **KSP Management Structure:** It is assumed that the basic management structure of several large radio surveys being undertaken now (e.g. VLASS on the VLA, Wallaby on ASKAP, MIGHTEE on MeerKAT and others) is representative of that for a medium KSP. The adopted science leadership categories consist of KSP leads, executive committee members, working group (WG) leads, and team members. We broadly define the latter category as the individuals who have proprietary access to the data before it is publicly released. A medium KSP is assumed to have 2 leads, a 5-member executive committee, 10 working groups, and a survey team of 100. The number of leadership positions is assumed to scale with KSP size such that, on average, a small KSP has 50% fewer leadership positions and a large KSP has 50% more leadership positions within its management structure relative to a medium KSP. This management structure combined with the observing assumptions described above produces estimates for the number of leadership positions over a 10-year period across the project as a whole shown in the top portion of Table 3: in aggregate there will be over 90 KSP leads, almost 700 exec members + WG leads, and ∼4500 team members.

- **Scientific Leadership Currency:** It is assumed that scientific return on investment into KSPs will be calculated using a science leadership currency. It is logical to assume that the "valuation" of this currency will balance the relative rarity of a given leadership category against the management workload associated with it. While the concept of a currency has been broadly discussed before, there appears to have been no previous attempt at estimating its valuation. The general approach and specific valuation adopted here is as follows.

[5] See Table 2 of SKA-TEL-SKO-0000007, "SKA Level 0 Science Requirements".

Table 3. Results: KSP Science Leadership over 10 Years

Observatory-Wide				
Role	**Small**	**Medium**	**Large**	**Total**
Leadership	21	40	30	91
Exec Memberships	53	100	75	228
WG Leads	105	200	150	455
Team Memberships	1050	2000	1500	4550
6% Proportional Participation				
Role	**Small**	**Medium**	**Large**	**Total**
Leadership	1	2	2	5
Exec Memberships	3	6	5	14
WG Leads	6	12	9	27
Team Memberships	47	94	141	282
6% Participation, Lead-Heavy				
Role	**Small**	**Medium**	**Large**	**Total**
Leadership	3	5	4	12
Exec Memberships	2	3	2	7
WG Leads	3	6	5	14
Team Memberships	38	76	114	228
6% Participation, Lead-Light				
Role	**Small**	**Medium**	**Large**	**Total**
Leadership	1	1	1	3
Exec Memberships	3	6	5	14
WG Leads	7	12	9	28
Team Memberships	63	126	189	378

NOTE—Scenario definitions are given in Table 2.

The basic currency unit is defined to be a medium or large KSP lead (ie. they are valued at 1), and a small KSP lead is valued at 1/2. The values of executive membership, WG leadership, and team membership scale relative to that for the leads of a given KSP, with valuations of 2/5, 1/5, and 1/50 respectively. It should be noted that both this approach and the resulting valuations are based on intuition rather than any concrete precedent (it is unclear that a precedent exists). However, these valuations combined with the KSP distribution and management structure adopted here imply that, across the project as a whole, each leadership category has a roughly equal value (ie. the currency divides equally between KSP leads, exec members, WG leads, and team members), which seems sensible. We return to the interplay between KSP structure and currency valuation in §4.

3. A CANADIAN CASE STUDY: 6% PARTICIPATION

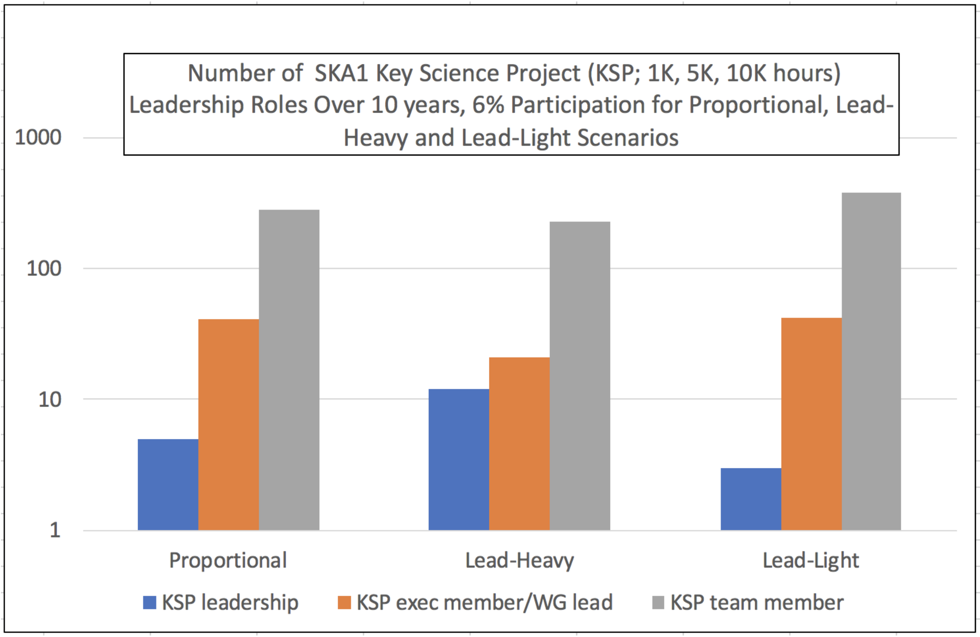

Figure 1. Canadian SKA1 KSP leadership opportunities over a 10-year period for a 6% participation level and the Proportional (left), Lead-Heavy (middle) and Lead-Light (right) scenarios summarized in Table 2.

Canada has long made clear its intention to participate in the SKA at a level of $4\% - 8\%$, a range that arises through a number of different considerations of scientific and technological capacity within the community. Canadian expertise in SKA-related science is both deep and broad, and Canadians are members of every SKA SWG. It is therefore anticipated that the Canadian community will have ambitions to take on scientific leadership roles ranging from leads to team memberships in many different KSPs over the course of a decade. A reasonable approach for a Canadian case study is therefore to estimate a plausible range of leadership opportunities for a 6% participation level in SKA1 by scaling from the 10-year project-wide numbers, since this should be representative in the mean.

The introduction of the science leadership currency allows for different expenditure scenarios to be examined in the context of a 6% participation level. Table 2 defines the different scenarios considered here, chosen to illustrate a reasonable range of options afforded by the currency construct:

- **Proportional scenario:** participation in each leadership category is simply proportional to the total number (which, given the currency valuation described in §2, implies that 25% of the available currency is spent on each of the four leadership categories adopted here);

- **Top-Heavy scenario:** more (50% vs 25%) of the currency is spent on KSP leads largely at the expense (15% vs. 25%) of executive memberships and WG leaderships relative to the Proportional scenario;

- **Bottom-Heavy scenario:** more (40% vs 25%) of the currency is spent on team membership at the expense (10% vs. 25%) of KSP leads relative to the proportional scenario.

To compute the implied number of leadership positions for each of these scenarios over a 10-year period, the (integer) number of leadership positions of a given category is computed starting with the most valuable (ie. KSP leads), and using any leftover currency in categories of less value (ie. exec memberships, then WG leads, then team memberships). This approach ensures that nearly all of the currency is spent in estimating the possibilities for each scenario. The resulting number of leadership roles for each scenario is given in Table 3 and illustrated in Figure 1.

Table 3 and Fig. 1 illustrate that the introduction of a science leadership currency produces a range of leadership possibilities for a 6% participation level: for the scenarios considered here, the number of KSP leads varies by a factor of four, and the combined number of exec members and WG leads as well as the number of team memberships vary by a factor of ∼two. This Canadian case study therefore implies that there is scope for some flexibility in tailoring the spectrum of leadership opportunities to the interests and expertise of the community. Which of the scenarios explored here (if any) are best suited to the Canadian community remains to be seen; this topic will be addressed in the context of LRP2020.

4. SUMMARY

This memo has provided estimates of the available SKA1 KSP science leadership opportunities over a 10-year period using a series of observing, KSP distribution, KSP management structure and science leadership currency valuation assumptions for a 6% participation level characteristic of Canadian ambitions. The Proportional, Lead-Heavy and Lead-Light scenarios considered here produce a range of leadership opportunities in which the number of KSP leads varies by a factor of four and the other leadership roles vary by a factor of ∼two.

While the methodology described in §2 certainly oversimplifies the KSP framework that will be established by the IGO Council, the case study in §3 suggest that a scientific leadership currency is a potentially useful construct for calculating scientific return on investment for KSPs. Despite its simplicity, the approach adopted here highlights the interplay between the valuation of that currency, which will presumably be in place before KSP proposals are solicited in order for SKA1 partners to understand the commitments of their members, and the KSPs that will ultimately be undertaken, which will presumably balance scientific merit and participation level across the project. The spectrum of KSP sizes and structures that will likely be required to accomplish the HPSOs may therefore be important to consider in valuing the currency; SWGs or the entities that supercede them once the IGO comes into force may be in the best position to provide this input.

Given the range of scientific leadership opportunities that the introduction of a currency affords, it will be beneficial for the Canadian community – with a breadth and depth of expertise and a small anticipated SKA1 participation level – to consider its KSP leadership ambitions and the scenario by which those ambitions can be fulfilled. LRP2020 and the SKA-related recommendations that will emerge from that process provide an opportunity for concrete discussions in this regard. It is hoped that the methodology and outcomes in this memo help inform those specific Canadian conversations, but also prove useful to a broad cross-section of SKA stakeholders across the project.

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