Annexure E: Human Resource Development to support SKA related activities in India

Long-term sustained activity and the success of India's participation in the SKA project crucially depends on the nation-wide active participation of a large and dynamic community from all levels – senior scientists to budding young researchers. Apart from making coherent and meaningful contributions towards the effort of building the telescope, continuing and expanding the activities of the different science working groups of the SKA-India consortium is indeed a basic requirement. Furthermore, communicating, sharing and showcasing India's ongoing SKA-related research activities is also extremely important to increase the visibility of these works, and to provide interested individuals with more information and details. Thus, human resource development has to be an obvious and integral part of Indian activities in relation to its national level engagement with the SKA project, and one of the most important tasks ahead for securing the country's place in the global scenario during the progression of the SKA era.

The SKA-India Consortium (SKAIC), formed in 2015, aims to bring the Indian community under a common umbrella "*for exploring, formulating, practicing and promoting activities related to the SKA project and its allied aspects, in India*". Currently, more than 20 major organizations from all over India are regular members of the Consortium through a Memorandum of Understanding (with an open call for admitting new members to take part in the SKA-India ventures). The Consortium coordinates the different scientific and technical SKA related activities (in collaboration with the various SKA International Organizations), as well as public outreach, education and training for user base development within the country.

The funds for supporting all human resource development (including education and public outreach activities), will be sanctioned and released through NCRA, based on recommendation of the competent authority/SKAIC, and shall be utilized within the prescribed procedure.

Activities planned by the SKA-India Consortium aimed at country-wide human resource development, have five different **(**interrelated**)** aspects:

(a) **Research training**: Currently, more than 150 researchers (faculty members, and postdoctoral and graduate students) from over 30 major participating institutions comprise the Indian contingent engaged in activities related to the building of the SKA and science with the SKA. To optimally utilize the benefits of India's participation in the SKA collaboration, these numbers are expected to be increased by a factor of 3 – 4 over the next decade. Members of the SKAIC will conduct programmes for the training of undergraduate and graduate students to work on various science and engineering projects directly relevant to the construction, operation and key science activities of the SKA. The existing UG and PhD programmes of the various member institutes from all over India have already been mobilized for achieving this goal of training and involving students in SKA related work (including work using data from the SKA pathfinders and precursors). However it is necessary to enhance and expand this effort. While a good fraction of the students will be supported through the already existing means and infrastructures of the

member institutions, funds are being sought here to provide exclusive support, at any given time, to 10 PhD/Integrated PhD students (~10% of the projected total PhD students expected to work with SKA India), including their fellowship, contingency grant and overhead support to the host institutes (preferably universities). These students will take courses that prepare them for specific SKA related work before taking up their research projects. Note that, these students will evolve to become the main users of the telescope during a very productive phase of their career viz., during the operation phase of the SKA. Early training and involvement will allow them to effectively take up various key responsibilities, and enable them to play leading roles at that time. The research training for SKA-India will be an inclusive and equal opportunity programme.

(b) **Postdoctoral fellowships (PDF) and Project assistants (PA)**: SKAIC will identify early career scientists with suitable background for SKA specific work, hiring them as postdoctoral fellows and project assistants to work with various science working groups. Currently only a few PDFs and PAs, working on SKA-related projects, are supported through individual initiatives by members of the SKAIC. SKA specific hiring of PDFs and PAs will allow us to attract bright young people, including the ones who are trained outside the country, to come and work in India for the SKA. Through the budget proposed herein, we plan to support ~75% of the projected total number of early career researchers, i.e., 22 PDFs and 3 PAs at any given time, spread across universities/institutes all over India. A few special postdoctoral positions with higher fellowship and other benefits as a part of this programme will also be considered. With prior training in related fields, they will be a major part of the workforce, that will support a faster integration of the Indian community with the intense, and tight time bound collaborative international activities in both the construction phase and the operation phase.

(c) **Organizing national level meetings/workshops/conferences**: As part of the country-wide human resource development programme, SKAIC will support regular meetings and conferences of the Indian community to present updates and plan further activities. This will include a dedicated session/meeting during the annual meeting of the Astronomical Society of India, as well as an annual SKA India meeting involving all the science and the engineering working groups. An international conference (with support from SKAIC) will also be hosted in India every three years to exhibit Indian contributions, exchange ideas and highlight results. Further, for training the younger generation and the sharing of knowledge, topical workshops at regular intervals, covering science and engineering aspects directly connected to SKA, will also be supported. Following the prevailing practice, SKAIC will extend support to such activities, with some auxiliary support from the respective host institute and partial industrial sponsorship, whenever possible.

(d) **Participation in international meetings/conferences**: It will be very important to have Indian representatives in various international meetings and conferences, to showcase results and contributions from the Indian community in both the scientific and the

engineering aspects. While the members of the science and engineering working groups will be encouraged to participate in such meetings using other available means, to ensure representation of the country, SKAIC will support the participation of Indian scientists to such meetings on a regular basis to present the work of their respective groups.

(e) **Education & Public Outreach (EPO)**: The SKA-India Consortium will carry out active public outreach and education activities all over India with three aims: motivating younger students from schools and colleges to pursue radio astronomy and become the future users of the SKA, making the common people aware of the importance and joy of the research work that will be done with the SKA as well as the involvements of the Indian community in it, and engaging citizens in an inclusive way to uplift the general scientific temper. We will take up a flagship programme to reach out to college and university students, particularly in rural and semi-urban areas. The EPO activities will promote socio-economic inclusion as well as gender equity. Through small workshops, they will be introduced to the ideas of radio (and multiwavelength) astronomy, and get hands-on experience of building low-cost radio telescopes and using those for basic observations. In a venture similar to the existing NCRA-IUCAA "Radio Physics Laboratory", it will also involve short training schools involving existing observatory facilities like the GMRT, Ooty Radio Telescope and those at the Gauribidanur observatory. These facilities, as well as other SKAIC member institutes, will also host a few college and university students as short term intern/project students undertaking technical work directly relevant to the SKA. These activities, by raising the level of interest of the students in both the engineering and science aspects of the SKA (and of radio astronomy in general), will have a long term impact on the creation of human resources for the SKA (as well as for various other purposes). Additionally, SKAIC will take up regular science communication and outreach programmes for the general public both via direct means (e.g. public lectures, exhibitions of posters, models and multimedia in meetings, conferences and other events) as well as via virtual communications (e.g. high quality content in website, online tool for citizen science using some GMRT data, social media presence, adequate communication via the press and the visual media). Overall, EPO will be taken up as a social responsibility by the Consortium for the enrichment of the knowledge base of students as well as the public.

It is important to note that, a common and pan-Indian UG/graduate training/exchange programme, for the three A&A mega-projects (SKA, TMT, and LIGO) that India is participating in, similar to/built upon the existing Joint Astronomy Programme (JAP) of IISc-IIA-RRI-ISRO, is under discussion. There are a lot of similarities in the broad requirements of the necessary coursework and training structure for these projects. This could become a very efficient and beneficial model by sharing resources from all three projects. The possibility of working together for some of the EPO activities (e.g. content generation for exhibitions or online activities) will also be explored.