Summary of risks and mitigation strategies

Introduction

- The SKA System Engineering Management Plan calls for CoDRs to include first draft risk registers and mitigation strategies.
- The system Risk Register (MGT-090.010.010-RE-003) explains the principles that have been adopted for the SKA project.

Risks identified in the CoDR documentation

- Risks, both programmatic and technical, have been identified in the documentation provided for most of the options.
- The following slides will highlight some of the risks and the proposed strategies to mitigate them.
- Many of the risks described apply to more than one of the described options.

Risks associated with the SKA dishes : development funding

- Insufficient development funding would limit the extent to which one or more dish options were further investigated or delay this process. This could result in a sub-optimal solution for the SKA.
- Potential mitigations include seeking alternative funding sources, extending the proposed development period, and combining the efforts of more than one development group.

Risks associated with the SKA dishes : production cost

- Dishes will be produced over a long period of time. Control of cost over such a long period will be difficult.
- Escalation of cost could lead to a significant de-scope of the project.
- Cost estimation must seek to anticipate the effects of the long term nature of the project and build in sufficient margins. The SKA should choose reputable sub-contractors with good long-term track records.

Risks associated with the SKA dishes : performance

- The SKA needs high performance dishes to meet the science requirements, e.g. imaging dynamic range.
- Failure to meet performance requirements would add extra cost, as dishes would need to be upgraded or replaced. This could result in de-scope of SKA science.
- The highest possible priority should be given to the early development work on SKA dishes to ensure that the chosen production design will be fit for purpose. This includes thorough analysis and test of candidate designs.

Risks associated with the SKA dishes : remote site

- The remoteness of the SKA site has implications for dish manufacture and maintenance.
- The difficulties associated with these activities could result in delays to the SKA schedule and escalation of costs.
- Very careful planning will be needed, drawing on the experience of industrial contractors with relevant experience. Cost estimates will need to take account of the difficulties likely to arise from the remote operation and include sufficient contingency.

Risks associated with the SKA dishes : environment

- The SKA will be operated in a very harsh environment. So far limited information has been made available about the candidate sites.
- If the production SKA dish design does not take full account of the environmental conditions then there will be an excessive need for maintenance and repair. The cost of this could result in de-scope of the SKA.
- Full environmental information must be provided by the sites and dish designs must take account of all expected environmental conditions to ensure that SKA requirements are fully met.

Risks associated with the SPF feed payloads: gaps

- To date there has been limited development work on SPF payloads for the SKA. Most of the work so far has been on feeds, particularly wide band feeds.
- Failure to produce timely designs for use in SKA payloads will result in delays to the SKA program.
- WP5 in the PEP phase of SKA must be suitably resourced to develop SPF payload designs that meet SKA1 requirements.

Risks associated with the SPF feed payloads: power

- SPF feed payloads will be deployed in large numbers. Use of cryogenics will result in high power consumption.
- Excessive power requirements may result in a suboptimal array because fewer receptors can be deployed within the SKA power budget.
- SPF feed payload development should include, as a high priority, exploration of design solutions that minimise the power requirement. This particularly applies to the cryogenic cooling system.

Risks associated with the SPF feed payloads: cost of ownership

- Capital cost of the SPF payloads is likely to be small compared to the cost of dishes. However, the operating cost, including power and maintenance cost could be very high.
- High operations costs, if encountered unexpectedly, could curtail science operations.
- SPF payload design activities must place great emphasis on maximising lifetime and reliability, and minimizing or eliminating the need for routine maintenance.

Risks associated with the SPF feed payloads: EMC, RFI, LNA stability

- Cryo cooler power supplies and control systems are a potential source of RFI. An oscillating LNA could radiate into all nearby SKA antennas.
- The resulting RFI could make some science observations impossible, either with the Dish Array or with Aperture Arrays nearby.
- It will be necessary to work with cryo cooler manufacturers to produce designs that do not generate harmful RFI.
- LNAs for the Dish Array SPF payloads must be designed to be completely stable under all operating conditions and over their operational lifetime.
- Very thorough RFI testing will be needed for all candidate SPF feed payload designs.

Risks associated with the PAFs

- The PAF Sub-System Risk Register identified 5 top risks:
  - PAF System Performance The performance of the PAF system may not meet the imaging dynamic range, spectral dynamic range, bandwidth or other functional requirements of the SKA.
  - Weight and Volume A PAF system that meets the performance requirements will not fit within the weight limit and space available on the antenna.
  - Power Consumption The power consumption of the PAF system is so high that the system cannot be operated within the assigned power requirements.
  - EMC and RFI Compliance The SKA site radio quiet zone may be compromised by RFI generated by the PAF receiver system.
  - Development Timeline Satisfactory PAF systems cannot be developed and manufactured in the time allocated in the project delivery schedule, PEP, SKA1 and SKA2.

Risks associated with the PAFs: System performance

- Insufficient continuum and spectral line performance would compromise the ability of the system to meet the science requirements of the DRM.
- Proposed mitigation:
  - Design studies include analysis of the PAF system as part of an integrated Dish Array.
  - Identify most significant contributors to dynamic range performance and allocate priority to requirements specifications in these areas.
  - Develop and implement suitable requirements specifications at system and sub-system level with particular attention to those requirements which affect imaging and spectral dynamic range.
  - Continuous evaluation of the system during the rollout phase to identify systematic errors that are likely to limit performance.

Risks associated with the PAFs: Weight and Volume

- Possible impacts are exclusion of PAFs from the SKA (reducing survey capability), de-scoping of PAF performance (reduced science) or re-design of dishes (excess cost).
- Proposed mitigation:
  - Experience gained with the pathfinder instruments must be transferred to the SKA system design
  - PAF system design is considered as an integral part of SKA antenna design studies. **Penalty** - Increased system design cost and longer design time.
  - Develop and implement suitable requirements specifications at system and sub-system level with particular attention to weight and volume of the PAF system.

Risks associated with the PAFs: Power consumption

- Higher than expected power consumption for PAF systems may increase operational costs resulting in:
  - Reduced array performance because fewer PAF systems can be operated within the power budget.
  - The operational costs so high the PAF system cannot be operated within the operating budget.
- Proposed mitigation:
  - Modelling of integrated PAF system power consumption enabling refinement of power consumption estimates.
  - PAF system design optimised to reduce power consumption.
  - High levels of integration used as a means to reduce power consumption
  - The number of RF channels is reduced. **Penalty** – Reduced PAF system performance.

Risks associated with the PAFs: EMC and RFI Compliance

- RFI generated by the PAF system may have significant impact upon the ability of PAF, Single Pixel, and Aperture Array receiver systems to meet the sensitivity required by the science DRM.
- Proposed mitigation:
  - A range of receiver system architectures investigated to minimise RFI or locate potential RFI sources away from the focus of the antenna. **Penalty** – Increased PAF system development cost; some architectures have higher manufacturing and/or operating costs.
  - PAF system design optimised to minimise RFI emissions. **Penalty** – Increased PAF system manufacturing costs.
  - High levels of integration used as a means to reduce RFI emissions.
  - EMC requirements developed and implemented at system and sub-system level.
  - RFI and EMC compliance of all system and sub-systems components verified.

Risks associated with the PAFs: Development timeline

- PAF systems are not included in SKA1 or SKA2 significantly limiting the amount of science that can be performed by the SKA.
- Proposed mitigation:
  - PAFSKA consortium set up to draw on the experience and expertise of the various groups currently working on PAFs.
  - Continuous engagement with the precursor array(s) being developed and other pathfinder activities to ensure that all risks are identified and addressed as early as possible.

Risks associated with the SPF Receiver

- The SPF Receiver Risk Register identified 5 top risks:
  - 1.0.1 Gain/Phase Stability The SPF Receiver system gain and phase are not stable enough to allow calibration on a suitable calibration cycle time.
  - 1.0.2 Dynamic Range The dynamic range of the SPF receiver system is not sufficient to meet the system requirement.
  - 1.0.4 Technology Maturity A range of possible receiver technologies have been demonstrated to various degrees but integration on a scale necessary for the SKA is yet to be achieved.
  - 1.0.6 Power Consumption SPF receivers that meet the performance requirements of the SKA cannot be operated within the assigned power requirements.
  - 1.0.7 EMC and RFI Compliance The SKA site radio quiet zone may be compromised by RFI generated by the SPF receivers.

Risks associated with the SPF Receiver: Gain/phase stability

- Insufficient gain and/or phase stability would affect the ability of the system to meet the dynamic range requirements of the DRM. The result could be the de-scoping of the science that can be achieved.
- Proposed mitigation:
  - SPF Receivers modelled and designed as part of an integrated system.
  - Develop and implement suitable requirements specifications at assembly and sub-assembly levels with particular attention to stability of components in the RF signal path. **Penalty** - Increased power consumption; increased temperature stabilisation required; increased weight; increased construction and operating cost.
  - Performance verification of assembly and sub-assembly performance to ensure performance requirements are met. **Penalty** - Increased verification and testing delays development and increases construction cost.

Risks associated with the SPF Receiver: Dynamic range

- Insufficient dynamic range would affect the ability of the system to meet sensitivity and linearity requirements within the assigned budget. The result may be de-scoping of the science that can be achieved with SPF systems and/or increased construction and operating costs.
- Proposed mitigation
  - SPF Receivers modelled and designed as part of an integrated SPF sub system.
  - Reduced instantaneous bandwidth to ensure dynamic range is achieved. **Penalty** – Increased complexity, manufacturing cost and control required to implement selectable band limiting filters.
  - Performance verification of assembly and sub-assembly performance to ensure dynamic range performance requirements are met.

Risks associated with the SPF Receiver: Technology maturity

- A suitable SPF Receiver system cannot be developed within the SKA1 and SKA2 development timeline or cost envelope. This could result in:
  - A significant de-scoping of the SPF receiver performance; reducing the science that can be performed by the SKA.
  - A significant redesign or modification to the SPF receiver to enable the receiver increasing the development cost and/or delaying the SKA.
- Proposed mitigation:
  - A range of possible SPF Receiver architectures investigated using technologies with varying levels of technological risk, different cost envelopes and levels of maturity. **Penalty** – Increased SPF Receiver development cost; some architectures may have higher manufacturing and/or operating costs.

Risks associated with the SPF Receiver: Power consumption

- Higher than expected power consumption results in increased operating costs. This may:
  - Reduce in the number of antennas that can be operated within the operating budget.
  - Require a significant de-scope of the SPF receiver performance to meet the power consumptionrequirement. This will reduce in the science that can be performed by the SKA.
- Higher than expected power consumption results in a significant redesign or modification to the SPF receiver to enable the receiver to meet the power consumption requirements.
- Proposed mitigation:
  - Modelling of integrated SPF Receiver power consumption enabling refinement of power consumption estimates.
  - SPF Receiver design optimised to reduce power consumption.
  - High levels of integration used as a means to reduce power consumption.

Risks associated with the SPF Receiver: EMC and RFI

- RFI generated by the SPF receivers may have significant impact upon the ability of PAF, Single Pixel, and Aperture Array receiver systems to meet the sensitivity required by the science DRM.
- Proposed mitigation:
  - A range of receiver system architectures investigated to minimise RFI or locate potential RFI sources away from the focus of the antenna. **Penalty** – Increased SPF receiver development cost; some architectures may have higher manufacturing and/or operating costs.
  - SPF receiver system design optimised to minimise RFI emissions. **Penalty** – Increased SPF Receiver system manufacturing costs.
  - High levels of integration used as a means to reduce RFI emissions
  - EMC requirements developed and implemented at assembly and subassembly levels.
  - RFI and EMC compliance at all assembly and sub-assembly levels verified.

SKA
SQUARE KILOMETRE ARRAY

END