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GUIDELINES FOR PROCUREMENT FOR WORK PACKAGE 2

INAF

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1. Acquisition requirements for SKA

The word "acquisition" denotes the totality of:

- *setting the requirements for a new equipment, facility or service;*
- *procuring that equipment, facility or service;*
- *supporting it through-life - through to its disposal or decommissioning.*

The results of acquisition depend on the correct and smart balancing of requirements, market capabilities, commercial processes, and impact in a major way on acquirer's ability to meet its goals, both technical and economical.

When requirements come from engineering, they tend to favour technical and performance aspects, and often do not take into account elements affecting total life cycle operations and costs. In the science arena, a common approach is to give specifications requiring process or product customisation which is both costly and difficult to maintain over the project life cycle, and which could be avoided with a sound knowledge of the market.

Acquisition must be conducted in such a way to deliver projects which meet or exceed the time, cost and performance targets which were set when the decision to proceed with the project was made. Its principles must include:

- A decision whether to acquire against 'output-based specifications' (OBS), or the more traditional 'build to print' (BTP) approach, or a combination of both;
- A whole-life approach to achieving value for money, rather than considering only initial purchase costs;
- A clear understanding of the roles of internal and external "customer" and "supplier" organisations, and supply chains;
- Application of modern best practice from the public and private sectors.

An effective acquisition process must also be *smart*, in the sense that it must have specific objectives, have performance requirements itself, set achievable targets, apply acceptable risk, and deliver results that meet the project timelines. Moreover, the process needs the right balance between effectiveness, time and whole-of-life costs, whilst cutting the time for key technologies to be introduced into the front-line.

Of course, requirements may change during the course of a major project, owing to technological developments or as a result of lessons learned from recent experience. The risks associated with such changes can be reduced through *Incremental Acquisition*. This *Smart Acquisition* principle aims to develop systems which can be upgraded in a planned way, bringing an initial baseline capability into service early and then progressively incorporating evolving technology as it becomes available.

Three other important guiding principles characterise *Smart Acquisition*. The first is that there should be substantial investment in defining needs during the early stages of a project, the aim being to reduce as far as possible elements of risk before performance, cost and time parameters are set. Second is a greater willingness to identify, evaluate and

implement effective trade-offs between system performance, costs and time. And thirdly, effort should be made to identify opportunities for 'commercial-off-the-shelf' (COTS) solutions wherever possible.

Central to Smart Acquisition are *Integrated Project Teams* (IPT), each formed to design, acquire and support a particular capability. Each IPT comprises personnel drawn from key specialist areas, including requirement definition, technical, financial, quality assurance, contracts and logistics experts.

1.1 Main topics of the SKA affecting acquisition

The SKA, from the project and industrial points of view, is much more challenging than other mega-science projects within the same cost range. In comparison with other astronomical projects, such as E-ELT, ALMA or LOFAR, and even other international science projects, like ITER or LHC, the SKA is much more complex. For example;

- Number of subsystems, and the challenge of connectivity;
- Dimension of the system: requires standardisation and mass production of low cost components;
- Time of delivery: relatively rapid roll-out in industrial mode;
- Remote, undeveloped, environmentally harsh desert, with widespread sites: impact on transportation costs, logistics, monitoring, maintenance costs, operation costs, reliability;
- Duration: requires ability to support uptime and upgrading with technology evolution for 50 years;
- Electrical power supply is expected to be a major cost element, with problems of wide area distribution, and green energy could be *de rigour*;
- Communications infrastructure could be cost challenging, especially if not fully utilized at the beginning;
- Management of Radio Frequency Interference (RFI) during construction will be especially challenging if the facility is operational during expansion.

Finding and working with the aerospace market and suppliers is a vital task to find companies with the right technical competences and/or production capabilities, i.e quantity and rates of production, processes, and costs.

Design for Manufacture (DFM) will play a large role, to reduce cost but maintain quality, simplification (by reducing parts count), minimise and standardise field assembly, easy shipping/transport, and long design-lifetime. This implies that up-front investment in fabrication tooling and facilities will likely be required.

Antenna systems will require novel design and fabrication techniques to improve cost/performance, and considerable infrastructure support (protection, temperature control, power systems, etc.) will be needed.

As an international project, the SKA must develop a fair and industry friendly policy, suitable to gain advantage from wide international collaboration and sensitive to the interests of stakeholders, especially the major funding partners.

In the current preparatory phase of the project, decision-making and management processes are still developing and focused on technical aspects. It must be considered that the next Phase will be characterised by a more structured and formal collaboration among the participating countries, institutions, and principal suppliers. Acquisition for the SKA will need to take into account and manage constraints coming from its multinational status. For that reason it is necessary to define a clear and consistent approach for industry involvement and acquisition processes.

1.2 Requirements for acquisition in multinational projects

Multinational projects, especially research projects, bring together a number of countries and institutions to reach a common objective. The advantage of gathering effort from many sources is not only to collect the required economic resources, but also to put together intellectual and technical resources from public and private sources for strategic benefit.

This implies that every participating organisation/country must be an active part of the project according to its capability, and to give an effective contribution to the common effort. For this reason the acquisition process must be carried out according to clear and widely accepted principles, defined in order to guarantee the success of the enterprise and satisfaction to the parties. It is necessary to define a set of agreed general criteria to avoid a situation where particular organisations or countries may act in such a way either to gain undue advantage over other participants or to reduce the effectiveness of the overall acquisition actions.

1.2.1 Value for money

An effective acquisition process offers assurance to the acquiring organisation that it will meet its goals. The simplistic ‘lowest price’ criterion is unable to grant neither the lowest total cost of ownership (costs over the whole life cycle) nor project life performance. The decision criteria must consider project quality and performance, in relation with other requirements including economic value, reliability, supportability, purchase risk, and price. These criteria combine to offer best ‘value-for-money’ acquisition.

The best value-for-money option entails balancing what is being offered against the price being asked. In many cases, better value for money can be achieved by paying more to get a more suitable product or service, or achieving earlier or more reliable delivery. More, generally, there are a number of factors that determine whether a proposal provides value-for-money, including:

- the capability of the supplier to deliver to the agreed terms, where possible assessed on the basis of past contractual performance;
- the extent to which the product on offer meets or exceeds the specifications sought;

- the flexibility to adapt to possible change over the lifecycle of the product or service, including the extent to which it can be evolved to meet future capability needs;
- financial considerations including all relevant direct and indirect benefits and costs and risks over the whole procurement cycle;
- evaluation of the risks associated with the alternative choices;
- the cost-benefits of an accelerated delivery schedule;
- An avoidance of a 'faster-better-cheaper' mindset by procurement agencies or suppliers.

All of these factors are relevant to determining the source that is best placed to meet the acquiring organisation's needs, within budget, and at an acceptable level of risk. In practice, there is more to securing 'value-for-money' than simply comparing the options. Equally important is choosing the right *method* to engage early with potential suppliers to ensure an effective environment that leads to successful and mutually advantageous procurement.

1.2.2 Specifying requirements – inputs or outputs

Traditionally, contracting organisations tended to write into specifications a large number of detailed facts about the nature of the product they wished to acquire, e.g. material, circuit designs, assembly methods, etc. This represented a concentration on stipulating how suppliers should go about providing what was physically required, rather than what it should do.

An alternative modern approach concentrates on what is required in terms of the final capability or performance, and is largely unconcerned with the detail of the product or service beyond obvious limits of physical size or power draw, etc.

The traditional approach (build-to-print), while having its place in acquisitions where various suppliers must each deliver numbers of identical product, often disregards contributions or innovation that can come from the market, and can require changes in suppliers' processes, with added costs. A most effective way to involve the market in effective acquisition is to specify the required performance or outputs, leaving the supplier greater freedom to determine how best to deliver the desired outcome.

1.2.3 Whole-Life Approach

It is often the case that the initial purchase cost of an acquisition is only a fraction of the cost of operating or maintaining it throughout its life. The figures can be particularly startling for complex equipment with a long service life, such as the SKA (50 years).

The whole-life approach is a key principle of an effective acquisition process. Project procurement teams need to establish the *Whole-Life Costs* (WLC) and annual *Cost Of Ownership* (COO) of the solutions under consideration for meeting a capability requirement, so that investment decisions are not founded or decided on just initial purchase cost.

Where the supplier is responsible for making the initial capital investment and then operating and maintaining the equipment or facility for several years, WLC considerations are an essential part of the bidding and subsequent contract negotiation processes.

1.2.4 Transparency and fair competition

Experience shows that, where feasible, competition between potential suppliers is the best way to achieve cost-effective delivery of goods and services. Competition provides suppliers with strong incentives to innovate and improve their performance. Just as importantly, competition can offer a benchmark for supplier performance, giving it the basis to reduce costs, improve the overall package offer and quality across the industry as a whole and demonstrate value-for-money.

In order to be effective, the competitive environment needs to be fair, in the sense that all suppliers are able to compete effectively, are given the same opportunity, with equal information, knowledge and support. Moreover, every competing company must understand that competition will be exclusively on the base of 'value for money' of their proposal. In other words, fairness of the acquisition process must always be granted.

This means that acquisition procedures must be transparent, in terms of information, timeliness, criteria and judgement, and competitors may be allowed to access all relevant information, in order to avoid unfair advantage to one or more bidders.

Accountability and transparency involves taking steps to support appropriate scrutiny of the procurement activity. This provides assurance that procurement processes undertaken by agencies are appropriate and that policy and legislative obligations are being met.

Officials undertaking procurement are accountable for complying with relevant policies and legislative requirements. They should ensure that they are aware of all relevant policies, legislation and agency-specific requirements that affect a procurement activity before commencing a procurement exercise.

Documentation is critical to accountability and transparency. It provides a record of procurement activities and how they have been conducted, and facilitates scrutiny of them. Procurement officers should maintain sufficient and appropriate documentation for each transaction to fully support the reasons for the procurement, the process that was followed and all relevant decisions, including authorisations and the basis of those decisions. By way of example, a process satisfying the requirements of ISO 9001:2000 would be encouraged.

Short-listed competitors must be offered feedback from their offers, with the aim of providing confidence in the process that has been undertaken, and reassurance that the purchasing agency is promoting efficient, effective and ethical procurement activities that are transparent.

1.2.5 Ethical issues

Ethics are the moral boundaries or values within which officials work. Employees must act ethically at all times. Ethics in procurement impacts to relations with suppliers, internal clients, stakeholders.

To enable buyers and suppliers to deal with each other on a basis of mutual trust and respect and conduct business fairly, reasonably and with integrity, procurement must be conducted in an ethical manner.

Officials involved in procurement, particularly those dealing directly with suppliers, should ensure that they:

- recognise and deal with conflicts of interest;
- deal with suppliers even-handedly;
- consider seeking appropriate probity advice;
- do not compromise the standing by accepting gifts or hospitality;
- are scrupulous in their use of public property; and
- comply with the duties and obligations related to privacy, intellectual property and legislative regulations.

Procurement of goods and services should be conducted in a way that imposes the same level of accountability and responsibility on a service provider as would exist if the acquiring agency carried out the service itself.

1.2.6 Intellectual Property - General

Generally speaking, intellectual property law aims at safeguarding inventors and other producers of intellectual output (e.g. designs, ideas, art) by granting them certain time-limited rights to control the use made of those productions. Those rights do not apply to the physical object in which the creation may be embodied but instead to the intellectual creation.

Intellectual property (IP) is traditionally divided into two branches, “industrial property” and “copyright.” The expression “industrial property” covers inventions and industrial designs. Simply stated, inventions are new solutions to technical problems and industrial designs are aesthetic creations determining the appearance of industrial products.

Like any other type of property, intellectual property can be owned, bought, sold or licensed. The existence of intellectual property that is not owned by the acquirer may prevent the acquirer from undertaking certain activities or using the IP in certain applications, unless permission is obtained from the owner of the intellectual property.

Intellectual property may be embodied in, or surround, technical data, an invention or other supplies. For example, intellectual property may be embodied in reports and notes, computer software, data, specifications, designs, drawings, models, photographs or other images. It is necessary to ensure that the acquirer not only obtains the rights to have the IP in question (e.g. hold, use, build, package, etc), but also to undertake certain activities or use in

defined applications (e.g. availability to sub-manufacturers, defined markets, bundled product, agreed branding, etc).

In the context of procurement, intellectual property is often categorised as being: Background, Foreground or Third Party.

- *Background Intellectual Property* is embodied in or relates to IP that exist prior to the commencement of the contract or is brought into existence other than in performance of the contract;
- *Foreground Intellectual Property* is created under or otherwise in connection with the contract. It may be co-owned by the collaborators if applicable;
- *Third Party Intellectual Property* is embedded in or is necessary to the supplies, but which is owned by a party other than the acquirer, the supplier or one of the supplier's major subcontractors.

Intellectual property may be necessary in order to support (use, maintain, modify, develop, manufacture) capability. Procurement officers should determine the ownership of Foreground Intellectual Property on a case by case basis in acquisition and support contracts. In most instances, acquirer will not require ownership of Background intellectual property and Third Party intellectual property but will instead seek appropriate licensing rights.

Factors that should be considered when determining who is best placed to own Foreground Intellectual Property include:

- identification of the party in the best position to exploit the Foreground Intellectual Property;
- estimation of the technological maturity of the supplies;
- analysis of future applications for the supplies;
- recognition of existing legal obligations; and
- assessment of value for money.

Circumstances in which it may be appropriate for the acquirer to own Foreground Intellectual Property include where:

- The technology is immature. The acquirer may need to retain ownership to keep its options open for the future development and application of the technology;
- The intellectual property has multiple applications. The acquirer may wish to retain ownership of the intellectual property to ensure exploitation of a range of possible, or desirable applications of the technology. In this case, acquirer might license suitable suppliers to commercialise particular applications of the technology.

Where the acquirer does not retain ownership of Foreground Intellectual Property, appropriate licensing rights, including the right to sub-license Foreground Intellectual Property should be secured to ensure that the capability can be developed and sustained. Ideally, a broad licence should also be sought, including the right to sublicense for Background intellectual property. The scope of the licence for both Foreground Intellectual Property and Background

intellectual property will vary based upon the complexity and risk level of the procurement, with more extensive rights being required as the complexity and risk levels increase.

For Third Party intellectual property, a licence on the best available commercial terms should be obtained.

Procurement officers must ensure that contracts permit access to all technical data that is necessary to enable it to exercise the intellectual property ownership and licensing rights under the contract. Contracts should nominate the delivery requirements for technical data including the form in which the data should be provided.

1.2.7 Policy issues

Procurement policies deal with the standards of behaviour in relation to external organisations, clients and suppliers, and other stakeholders, concerning market selection, supplier selection rules and methods, types of supplier relationships and methods of industry engagement. Procurement policies are tightly linked to ethical policies adopted by the organisation, and both should be made public and monitored over the time. The main issues in procurement policies are related to:

- If, when and how to involve suppliers;
- How to enforce healthy competition among suppliers;
- Acquisition methods and procedures, in relation to needs and markets;
- Relationship management and fair ‘value for money’.

As the final structure of the collective SKA consortium becomes defined, and the related governance rules established, it will be necessary to fully research and carefully define public procurement rules. Investigation of the policies and approach of other multinational organisations, such as ESO and CERN will be helpful. It will be necessary to define the acquisition policies for the SKA, such as:

- Firm but flexible procurement procedures, according with the legal entity that will carry out the project;
- Financial issues, such as payment terms and conditions;
- Legal frameworks for contracts and contract management;
- Ethical standards for procurement;
- Dealing with questions of ‘juste-retour’;
- Globalisation of industry;
- Trading currency and foreign exchange;
- Approved supplier lists;
- Supplier evaluation (and need for due diligence in reference checking).

2. Market capabilities

Large projects, especially if carried out by multinational or collaborating organisations, require a sound knowledge of markets to select the right suppliers for the various phases. A lack of that knowledge may turn a positive engineering outcome into a waste of money and effort.

For this reason, it is a priority of the SKA to acquire experience in investigating and assesing current global capabilities and future technology trends in the market covering the span of the SKA project both in relation to stakeholders and to countries and regions with identified capability as suitable suppliers or supply chain members.

2.1 Searching for sourcing opportunities

Knowledge of markets is acquired by means of procurement marketing (market analyses) and strategic sourcing activities, intended to:

"*satisfy an organisation's needs from markets via the proactive and planned analysis of supply markets and the selection of suppliers, with the objective of delivering solutions to meet pre-determined and agreed organisational needs*". (from: The Chartered Institute of Purchasing & Supply)

Specific issues to be defined are those related to the SKA industrial targets and how the market should be chosen to meet such targets. Those issues must be matched against the actual legal and economic frameworks (i.e. countries) of markets, the (likely) constraints to which the SKA consortium will be subject (e.g. fair returns to funding institutions/countries).

On the basis of project/consortium policies and technical and operational needs, it is necessary to analyse and evaluate markets to select suitable products and suppliers. This implies the consideration of different aspects of markets, both technical (availability of the sought industrial structure and its dimension) and non-technical issues, such as the political climate (e.g. policies for trade in aerospace technologies), economics, security and safety, laws and regulatory matters, logistics, geographical constraints, etc.

The tool to manage sourcing is the Procurement Plan that should capture the technical and economical requirements underpinned by market analysis and opportunity evaluation.

2.1.1 The procurement plan

"*The purpose of the Procurement Plan is to identify the context of the programme and to define the processes and procedures to be used to control the procurement of all subcontracted equipment and services. These processes and procedures are designed to ensure the placement of subcontracts on the most favourable terms, consistent with the needs of the project, ensuring that the level of commercial risk is kept to a minimum, with appropriately long term supply of conforming equipment secured for the duration of the Contract*". (from BAE)

The Procurement Plan sets acquisition strategy and helps guide program execution across the entire project life-cycle. The strategy evolves over time and should continuously reflect the current status and desired end point of the program. The strategy must be flexible enough to accommodate acquisition oversight decisions both on this program and on other projects that may affect this program. It should address the availability of required capabilities to be provided by other projects.

The acquisition strategy establishes the milestone decision points and acquisition phases planned for the program. The strategy should cover development, testing, production, and life-cycle support. It should prescribe the accomplishments for each phase, and identify the critical events affecting program management.

If the program manager decides to incorporate concurrency in the program, the acquisition strategy should discuss the benefits and risks of the concurrency and address the resultant risk mitigation and testing impacts.

The Procurement Plan starts in the first stages of a project and follows its entire evolution, describing (or even translating) the WBS/PBS (Work Breakdown Structure)/(Product Breakdown Structure) in procurement specifications consistent with markets, suppliers, project/consortium policies.

Technical and operational requirements must be used to define supplies, their characteristics, scheduling of deliveries, logistics, legal items, etc.

Depending on the structure of markets and supplies, different procurement strategies could be defined and implemented. Developed in coherence with procurement marketing, strategies must be consistent with engineering and operations needs, and must give economic and technical advantages to the SKA.

The general Procurement Plan takes into account the relevant supplies required to carry out the assignments. For each main supply, the plan should consider:

- *Requirements* – definition of the supply in terms of technical requirements, logistics, quality, delivery times, services, implications deriving from total life cycle considerations;
- *Market* – characteristics of the suitable suppliers, number, locations, regional limitations or advantages, quality management, discussion of post-contract support services, obsolescence, etc.;
- *Risks* – critical supplies, impact on the overall delivery, mitigation strategies;
- *Organisation* – roles and task assignments to carry out the procurement processes (including due diligence of suppliers) up to the fulfilment of requirements;
- *Product Breakdown* – analysis of the components required to produce the supplies at the best cost/performance ratio, giving the check list of components and a cost model for supplies;
- *Contract Awarding Processes* – depending on the type and characteristics of the supply, adequate procurement processes (in terms of efficiency, efficacy and compliance to laws and regulations) must be devised and promulgated;

- *Contract Administration and Closeout* – methods, procedures, responsibilities to carry out the delivery in compliance with contractual terms and goals of the project.

2.1.2 Procurement Marketing

Procurement Marketing is the process devoted to developing a systematic knowledge of markets and market opportunities. It allows the understanding of how markets work and do business, how strategies are devised to select suppliers and acquire products, suggests suitable relationship models with suppliers, and risks mitigation strategies.

Procurement marketing supplies business intelligence to procurement managers to optimise the acquisition results. It is informed by the definition of the procurement mix, i.e. what is required and when, technical and economical requirements, etc. The task is incremental, following market requirements while WBS/PBS is developed. Typical issues include:

Market survey: evaluation of needs principally at the systems level (what and how much) and requirements (characteristics, performance, target costs, etc.) and the selection of suitable markets able in principle to satisfy those needs. It studies geographical markets searching for products and suppliers, pointing out market structure, business characteristics, and risks. Its output is knowledge, and the main tasks are:

- Collecting and analysing project needs per industrial segments;
- Selecting accessible markets where there are major opportunities to satisfy needs;
- Analyses of the industrial systems in the selected markets, their capabilities, performances, development, etc.;
- Evaluation of the dimension and characteristics of the affordable offer on the selected markets;
- Evaluation of markets and country stability (political, economical, social, etc);
- Analysis of the logistics (structures, costs) required and available to acquire products;
- Evaluate the regulatory and fiscal environment derived from commercial relationships in the selected markets.

Business intelligence/industry engagement strategies: evaluation of the supply market in terms of business strategies and critical factors able to influence business relationships. In order to optimise results of acquisition strategies, it is necessary to know how players in the market do their own business, and how those strategies depend on specific cultural, political, economic factors.

- Evaluate the economic dimension and the degree of development (both technical and organisational) of suppliers in the market;
- Select the major players in the market, and analyse their model of business. Research attitudes and approach to pre-tender strategic engagement through R & D collaborations, project reviews, embedded personnel, specialist training etc.;
- Find out strategies necessary to involve regional industry parties, policy makers, decision makers, in business relationships.

Products/Suppliers selection: selection of the most suitable suppliers in relation to needs and strategic acquisition. The suitability of a market comes from its ability to offer an adequate number of suitable suppliers. Procurement marketing selects markets and the relevant business opportunities that are worth to be considered and evaluated in a later stage of sourcing.

- Evaluate suitability and accessibility of products and suppliers on the market;
- Analyse the products/suppliers to find out potential sourcing opportunities.

Risk analysis: detection of market risk potentially able to endanger business goals, and supplier performance. Risks occur in the actual acquisition of products. In the procurement marketing phase, mainly at scouting level, it is necessary to specifically investigate elements of weakness in the target industrial or national systems.

- Evaluate risk factors of the investigated market, in relation with their potential use;
- Evaluate effects of potential risk factors on the goals of the acquiring organisation;
- Define and evaluate cost/results of possible mitigation strategies and actions.

2.1.3 Sourcing

Procurement marketing gathers information and knowledge about markets and gives an evaluation of their potentiality in relation with internal demand. Sourcing takes this information and goes deeper into evaluating market opportunities to be transformed in actual acquisition opportunities.

Evaluation of suppliers' suitability: selected suppliers are scrutinised to investigate the main characteristics of their organisation/offer in order to determine what and how much they can by employed.

- Evaluate suppliers' dimension and capabilities;

- Determine suppliers' ability to support the acquiring organisation over the defined time horizon;
- Verify the ability to support evolution needs of the organisation.

Capabilities evaluation: in order to optimise acquisitions, it is necessary to understand the core competences of suppliers, and measure, in some way, their ability to meet requirements in terms of quantity, quality, cost and performance – value-for-money.

- Determine core business and business dimension of the selected suppliers;
- Evaluate the production structure, skills, tools, equipment, quality management, customer base, financial capacity, etc;
- Measure suppliers' characteristics against needs and requirements;
- Evaluate the ability of selected suppliers to satisfy needs (dimension of accessible output against dimension of needs). **The total offer cost.**

2.2 Risk analysis and problem avoidance issues

Effective risk management is integral to efficiency and effectiveness of project management, enabling agencies to proactively identify, evaluate and manage risks, opportunities and issues arising out of procurement related activities. Risk management involves the systematic identification, analysis and treatment, and, where appropriate, acceptance of risks. Risk is a part of the environment within which agencies operate and proper risk management is an important element in achieving successful outcomes.

The resources expended in managing risk should be commensurate with the likelihood of a loss or benefit. In contracts, the risk should lie with the party best able to manage that risk.

Risk is defined as the chance of something happening that will have an impact upon objectives. A Project risk is a chance of something happening that could impact (positively or negatively) on the achievement of a successful project. Risk is measured in terms of the probability of an event occurring and its consequences.

As significant risk may arise in procurement processes and a documented risk management plan should be required. Even a basic table of thought-through risks and their mitigation can be useful. Failure to adequately identify the risks and develop adequate strategies to manage those risks may result in:

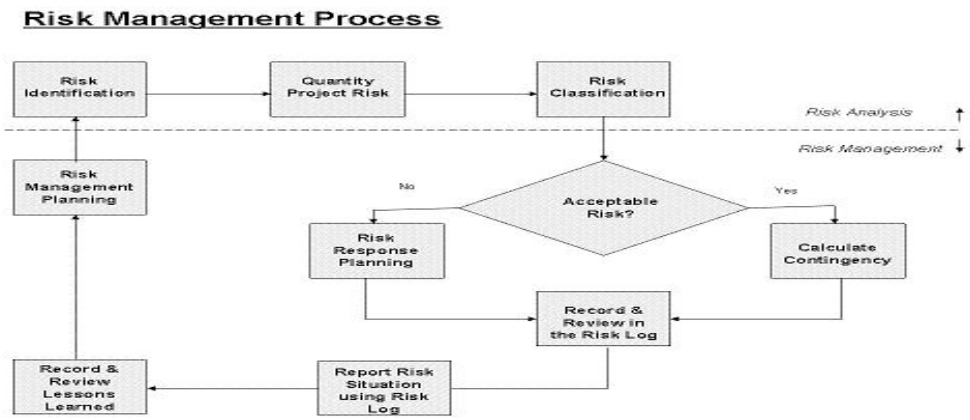
- the selection of a supplier not capable of delivering the required outcome;
- contract cost overrun;
- delays in the delivery schedule leading to an overall time overrun on contract completion;
- failure to meet the desired quality of contract deliverable;
- need for the acquiring organisation to step-in at increased project costs;

- non-achievement of identified requirement; and/or
- not meeting the sponsor/client's expectations.

Some of the factors in mega-science projects that may increase procurement risk exposure include:

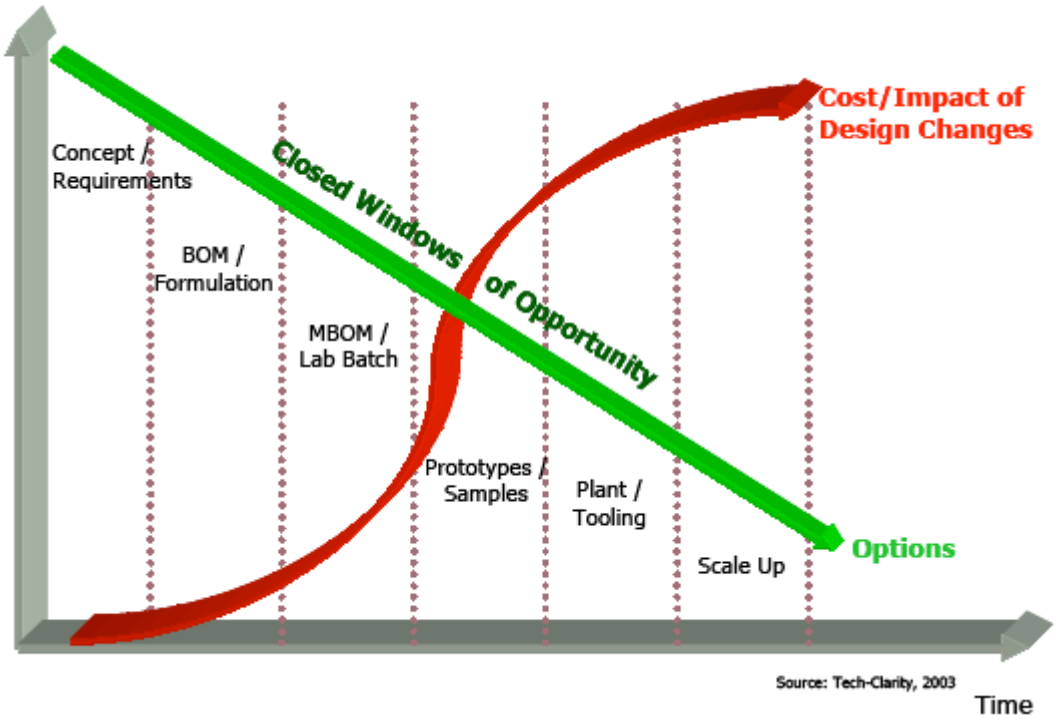
- the maturity and complexity of the technology;
- heavy dependency on Information Technology (IT);
- the extent of integration with other systems or services;
- the level of requirement being met by Commercial of the Shelf (COTS) or custom products;
- inadequate or poorly written specifications and/or selection/evaluation criteria;
- inadequate, or still developing, staff skills; or a dependence on a small number of key personnel;
- potential for breach of ethics and probity in the tender evaluation process;
- environmental (institutional, geo-political) issues surrounding the project;
- the timeframe identified for development/delivery (the longer the timeframe, the greater the risk);
- inadequate acceptance criteria; and
- in-service support requirements/costs;

The risks identified, and the strategies to manage them (including lessons-learned from comparable projects), will be peculiar to the circumstances of each procurement. Using a formal risk management process will assist in the identification of the risks likely to be encountered and will document the appropriate strategies to manage those risks. This information is normally incorporated into a Risk Management Plan which is a dynamic document requiring regular review and updates. Below is a diagrammatic representation of an effective risk management processes.



3. Design costing effects in market procurement

Research from DARPA (US Defense Advanced Research Projects Agency) shows that most product costs are locked in early in the design process. However, design engineers can often make design decisions without having visibility into adequate sourcing information. As a result, they frequently do not have a thorough understanding of total product cost, that is, a view of product cost that goes beyond direct material cost, incorporating production tooling, logistics, tariffs, cost of quality, available supplier capacity, lead times, and other profitability drivers. Nor do they routinely have visibility into the complexity of supply risk, vendor performance, forward costing, and related supply issues. Failure to apply procurement considerations when engineering changes are made often compounds these problems.



Alternatively, involving procurement expertise earlier reduces the number of iterations required by engineers, regulatory compliance, and sourcing functions and, thus, results in faster product procurement, lower development cost, and, ultimately project success.

The view to realistic product cost implications does not need to be so murky for engineers – and project organisations can take steps to achieve total cost management early in product design. The key is to enable 'Design For Sourcing' as a concept; the integration of procurement information and workflow processes into design. Research shows that best-in-class companies are incorporating sourcing decisions earlier in the product lifecycle and getting impressive benefits including reduced product cost, faster time to market, faster time to volume, improved quality, resulting in increased revenue.

Too frequently in R & D projects the final designs are delayed by protracted refinements, with accompanying sourcing realities forcing late tradeoffs in product designs. These tradeoffs can result in added costs, product delays, or even decreased product functionality.

The goal is to make design and engineering decisions with full visibility into sourcing information in the early part of the design process. The key to driving engineers to expand their design decisions to include procurement considerations is an actionable strategy. This may involve changing organizational structures and business processes. Relevant actions include educating (or reminding!) engineers on the impact of their decisions on cost; addressing sourcing decisions early in new product development and including them in engineering change processes; aligning and integrating design and procurement resources, processes, and supporting software (including providing visibility into total cost implications at the time of design); and making product cost a core product requirement – to name a few.

Achieving design for sourcing – and its benefits – relies on organizational synergy and process changes. Engineers will not naturally adopt an expanded approach that includes procurement considerations in design without an actionable strategy. To help instil the discipline and provide the required information, this strategy benefits from automating workflow processes that can provide engineers with ready access to robust cost data, supplied at the right time.

In addition, engineers must have a framework for analyzing costs more realistically. This view should include supplier information, geographic coverage, quality performance, and other supply considerations in addition to product performance characteristics. Providing sourcing information to Engineering does not substitute for professional Procurement expertise. In fact, it increases the need to make supplier and sourcing analysis available sooner and in a more readily consumable manner. However, providing this information can encourage better collaboration between Engineering and Procurement. This collaboration can take on many forms, including direct Procurement involvement in design processes and arming design engineers with better sourcing information.

Although encouragement is given to firms being involved in early stage R & D in partnership with designers, there is a risk that such interaction may 'lock-out' the company from subsequent RFT bids. To avoid this, early stage involvement should be undertaken with appropriate controls in place (e.g. documented 'Chinese walls'), and restriction of contact once the procurement process is underway.

A recommended structure for improving such collaboration within mega- projects in the *Integrated Product Team* (IPT). IPT membership is made up of multi-functional stakeholders working together with a product-oriented focus. This team is empowered to make critical life cycle decisions for the system. Because the product and system development activities change and evolve over its life, team membership and leadership will likewise evolve. While acquisition planners, project managers and design engineers may be the most prominent members early in the life cycle, provisioners and sub-system managers gain a bigger voice during engineering and manufacturing development. Equipment specialists and trades-people may be the lead members during the operations and maintenance phase, with the design engineers returning once again if a major modification is needed.

IPT key characteristics are:

- Team is established to produce a specific product or service;
- Multidisciplinary - all team members/functions working together towards common goal;

- Members have mutual, as well as individual accountability ;
- Integrated, concurrent decision making ;
- Empowered to make decisions within specific product or service goal;
- Planned integration among teams towards system goal;

The role of procurement in the IPT is to supply the knowledge about markets capabilities and evaluation, availability of suppliers and technology trends in order to effectively:

- Investigate alternatives;
- Evaluate risks and devise risk mitigation strategies;
- Evaluate total costs over the life cycle;
- Manage the procurement plan;
- Support in enforcing acquisition policies.

4. IP management and protection

Intellectual Property (IP) plays a critical role in the development and sustainment of SKA capability. Generally, IP associated with industry contracts related to the acquisition and support of capital equipment and technologies will need to be assigned or licensed to the SKA. In the case of IP derived through collaborations with SKA Consortia partners, the published Statement of Common Intent will apply. It is essential that documented IP arrangements are clear and reflect SKA IP requirements, however a 'legal-lite' (SKA memo 52) approach is recommended. As a minimum, SKA must have proper 'through-life' access to project related IP and supporting technical data to develop and support the capability by:

- Ideally, obtaining unfettered rights to project IP (refer SKA memo 80) for application in radio astronomy; or
- obtaining formal licences covering the IP and its application within the SKA project; and/or
- owning some elements of the IP and obtaining a licence for the remainder; or
- owning all the IP in appropriate circumstances;
- permitting modification and development of products and to sub-contract the manufacture the products subject to limitations agreed in the contract and listed in the IP Plan;
- security of IP access and control for the period of the project;

Where the IP is of a complete or substantial software nature ,or will have a wide usage across a number of platforms, the IP agreement will seek a licence for broad SKA purposes. This will enable the SKA to utilise licensed Foreground and Background IP for activities that

are not directly related to the products or technologies being procured or supported under the contract. For Third Party IP, SKA will seek a licence on the best available commercial terms.

The SKA project will determine the ownership of Foreground IP on a case by case basis in acquisition and support contracts. In most instances, SKA will not seek ownership of Background and Third Party IP but will instead seek appropriate licensing rights.

Where SKA elects to retain ownership of Foreground IP, appropriate clauses will be included in the request for tender (RFT) documentation and the negotiated contract. Where appropriate, these clauses may allow for the contractor or major subcontractors o be granted a licence to SKA owned Foreground IP.

Where the SKA project does not own the IP it must ensure that it has the right to sublicense the IP and should not allow itself to be locked into a sole source support arrangement with the Original Equipment Manufacturer (OEM). This is not to say there are instances where the OEM is not in the best position to support the supplies. However, for example, where a support contractor is performing poorly or is not competitive, the SKA project will generally retain the option to seek an alternate supplier.

SKA will seek similar ownership and licensing rights to Foreground and Background IP developed by major subcontractors. However, in some circumstances, SKA will require major subcontractors to enter into a deed of agreement with SKA to ensure that SKA is able to enforce its IP rights in relation to subcontractor developed IP.

Where SKA does not retain ownership of Foreground IP, appropriate licensing rights, including the right to sub-license, must be secured to ensure that the capability can be developed and sustained. SKA will also seek a broad licence, including the right to sub-license Background IP.

The agreed IP ownership and licensing rights must be recorded in an IP clause, or IP Plan attached to the contract. The purpose of an IP Plan is to detail the status of IP in the supplies, and in some cases broken down to a work breakdown structure level, and the consequent activities. The IP Plan should be updated as required during the contract period. The SKA procurement documentation will nominate the delivery requirements for technical data in the contract and may request that such data be provided in a particular form.

The SKA project will seek an indemnity from the contractor to safeguard the SKA against liability flowing from potential infringement of IP rights by third-parties, and where Defence agencies may exercise their sovereign right to use the IP in accordance with the legal ownership and licensing rights granted under some jurisdictions.

5. The Role of industry in PrepSKA

The SKA is a mega-science project to design and build a new astronomical instrument, capable of transformational science with a high potential in terms of innovative technologies and 'spin-off' opportunities. From this point of view, industry will not only serve as a supplier, but also as a collaborative partner and commercial exploiter in an exciting and challenging technological venture.

5.1 The advantages for industry to join to the SKA

There are many reasons why industry may wish to be associated with the SKA. These range from short-term financial gain via prototyping contracts in the development phase, subsequent large manufacturing and construction opportunities, through to more indirect motivations such as a wish to develop their business and staff in ways not routinely available. An earlier paper (SKA Memo 52), listed reasons encountered so far in the SKA project, including:

- The opportunity to grow and hone the creative energies of the best professionals in a highly imaginative project;
- The ability to perfect leading-edge techniques and products in a very demanding application, and to interact with technologically sophisticated users;
- The ability to generate and share information with other R&D partners – both institutional and industrial – in a benign and commercially non-threatening environment;
- The visibility flowing from association with an innovative, high profile, international mega-science project;
- The potential for early involvement and, directly or indirectly, favourable positioning in a € 1 billion project spanning a wide range of engineering and computing disciplines; and the opportunity to apply, for financial gain via negotiated licence agreements, IP generated within an SKA partnership to commercial activities outside the SKA arena.

From the perspective of SKA scientists and engineers, some benefits of early industry links include:

- The opportunity to obtain alternative viewpoints on the design and implementation of low-cost components and systems;
- The ability to call on specialist development and manufacturing teams during prototyping activities;
- The opportunity to learn first-hand, via relatively small-scale projects, the merits and pitfalls of working with external groups;
- The identification of enterprises able to deal with scale and complexity, and to build SKA know-how in companies likely to be bidders in SKA construction work packages; and

- The possibility of identifying project management and similar enterprises able to contribute to objective decision making processes, and to risk assessment and management within the international SKA project.

There are four main roles for industry in the SKA:

- As consultants/advisors;
- As contractors for pre-competitive R&D in association with SKA institutions;
- As commercial providers of goods and services for the construction and operation of the SKA, which will in turn boost their capabilities;
- As influential organizations (many with global presence) in the circles of governments and politics, who will assist in obtaining funding for the SKA if they see advantages for industry;

As a consequence, in order to guarantee the interests of all the stakeholders, success of the project, and the quality of scientific results, it is essential that the total industry involvement process is managed under acquisition policies that encourage and stimulate a strategic partnership 'win-win' approach in relation to both technical and economical goals.

5.2 Terms of reference to approach industry during PrepSKA

In the case of the SKA project, the procurement process will be performed after the PrepSKA (SKA preparatory phase) period, however PrepSKA work package 2 (WP2) is planned to deliver the SKA costed system design. To achieve this goal, a process for scouting markets for capabilities and technologies able to support the project is then needed. Therefore in terms of procurement, the responsibilities assigned to PrepSKA must be:

- research the global market and country capability opportunities;
- avoid problems such as vendor lock in/out;
- assurance to industry of fair competition/collaboration;
- assure stakeholders (funding institutions) of transparency in procurement processes.

The scouting process will require a systematic approach to identifying project needs against industry capacity/performance to be acquired in a fair competition framework. From a technical point of view, the approach is designed to provide the largest view of available technologies and capabilities able to best fit the SKA requirements. From a stakeholder point of view, the approach performed during the design phase, both for selecting technologies and releasing any kind of R&D contracts, should not introduce any bias that could affect industry competitiveness during the construction phases. Moreover, all the advantages reported in the previous section must fit into guidelines comprising a high level agreement among funding agencies and/or related governments.

Then, a set of rules that clearly identifies tools, players and decision making process can be set up in order to permit free gathering of technical support and advice from industry, versus stakeholder concerns about fairness in competition.

5.2.1 Interfacing with industry

The level and method of interfacing with industry will vary according to the stage of the project e.g. PrepSKA, production phases, through to operations should be considered in the context of:

- availability of sources for main components/categories suitable to be used in SKA
- capacity/capability of the industrial business structure
- constraints and limits to market accessibility
- markets and industrial technology trends
- the legal framework for local procurement and IP laws

In the earliest stages, there are four ways in which industry may be engaged, as shown in the following table 1:

Table 1: List of Industry Engaging Options

Option ID	Option Description
IEO-1	High level engagement, at the concept level, to discover new technologies or industrial information and skills
IEO-2	R & D contracts for prototyping & design
IEO-3	Global price enquiries for COTS requirements
IEO-4	*'In-kind'* contributions of personnel, tools, technical services, or other resources

The engagement options listed above will normally result in procurement of supplies or services through formal channels of selection, approval, and contract, e.g. collaboration agreements, Request for Quotation (RFQ), Request for Tender (RFT), etc. In practical terms, the industry capability scouting task will need to take account of the need to:

- involve the regional/country agencies to the appropriate extent
- be thorough enough to result in a meaningful assessment of capability
- be cost and time efficient

Generally, the ways of working and interfacing with industry will require a consistent and well managed approach in accordance with these guidelines to ensure fairness, efficiency, and effectiveness.

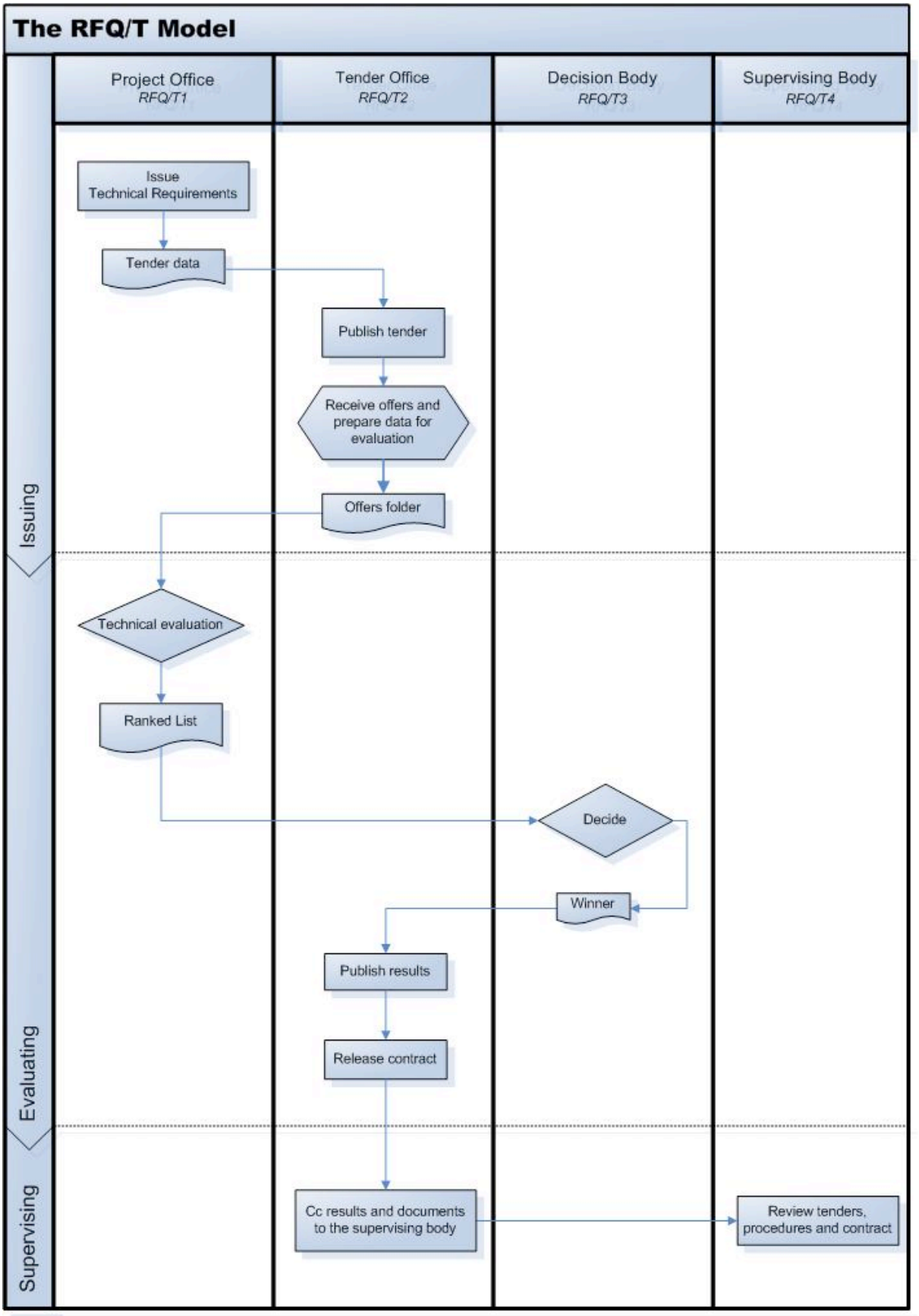
Although restricted, or closed RFTs – Request For Tenders, may be appropriate for certain supply acquisitions (i.e. where only one or few suppliers have been identified as possible bidders), open tenders are likely to be the preferred tool. This more likely guarantees both the largest numbers of industry enquiries, and a fair approach in gathering industrial information, supply offers, and R&D collaborations during the PrepSKA phase. Price enquiries and R&D contracts performed via open tenders could provide the following advantages:

- guarantee to the project office the full access to a worldwide market to identify the best available technologies, free from any geographical boundary restrictions;
- stakeholders can continuously monitor the industrial involvement for fairness.
- The ability to look strategically at regional capability for possible bundling or split of contracts, or to address '*juste-retour*' issues. Also, early 'chunking' of the project systems or subsystems may be appropriate;

The RFQ/T model requires the components shown in the following table 2:

Table 2: The RFQ/T components

Component ID	Component Name	Component Description
RFQ/T-1	Technical Office	issues needs and related technical document Provides technical evaluation of the offers
RFQ/T-2	Tenders Office	publish tenders data and related documents as well ensure that: 1. RFQ/T documentation is properly controlled, updates and clarifications are distributed equitably, tender offers are received officially and are secure until opened. 2. RFQ/T preparation is conducted according to set rules, and the RFT release process is globally fair.
RFQ/T-3	Decision Body	receives, ranks the offers and decides the winning one.
RFQ/T-4	Supervising	review on shortlisted or winning offers, with properly documented records of the decision process supported by factual and objective procedures


The RFQ/T Model
Project Office
RFQ/T1
Tender Office
RFQ/T2
Decision Body
RFQ/T3
Supervising Body
RFQ/T4
Issuing
Evaluating
Supervising
Issue Technical Requirements
Tender data
Publish tender
Receive offers and prepare data for evaluation
Offers folder
Technical evaluation
Ranked List
Decide
Winner
Publish results
Release contract
Cc results and documents to the supervising body
Review tenders, procedures and contract

5.2.3 Governance of Industry Involvement in the PrepSKA case

Due the long lifetime of the developing phase of the SKA project, the template workflow for governing the industrial engagement should be applicable even after the PrepSKA phase.

Starting from this standpoint, the deployment of the RFQ/T model for the SKA shall be be configured as shown in the following table 3 and the figure.

Table 3: The RFQ/T components

Component ID	Component Name	Component Description
RFQ/T-1	SKA Project Development Office	Technical Office
RFQ/T-2	Regional Industry Contact Tenders Office Industrial Relation Manager	Tenders Management System and Technical Evaluation Committee
RFQ/T-3	PrepSKA Board	Decision body
RFQ/T-4	Agencies SKA Group	Supervision Body

The RFT process will itself need to comply with international codes, e.g. the EC, WTO, etc.., and operate with approved procedures and templates. In the framework of the SKA, the RFQ/T model applied to the four A,B,C,D areas of previous section, should be deployed in the following way:

IEO-A. High level engagement at the concept level to discover new technologies or industrial information

Such approaches should involve Regional Industry Contacts, be covered by a standard MoU, with an appropriate an NDA - No Disclosure Agreement, approved by the PrepSKA Board. Industrial technical information coming from the pathfinders/precursors is important for the work of WP2 in providing a costed design. Liaison with the pathfinder/precursor organisations will occur through the SPDO Domain specialist meetings. When this involves transfer of technology, formal agreements will be put in place, including where possible unfettered IP agreements.

IEO-B. R & D contracts for prototyping & design

The project office will issue a specification (drafted by the technical domain), normally using an output specification, and encouraging innovation and emerging technologies. A copy will go to the Regional Industry Contact. The Tender Office will arrange the receipt of offers and send to the technical domain of the project office for ranking the bids, according to a standard protocol. The PrepSKA Board will evaluate

the offer and decide the winner and authorize the issue of the contract. The ASG will periodically review the procedures and the results.

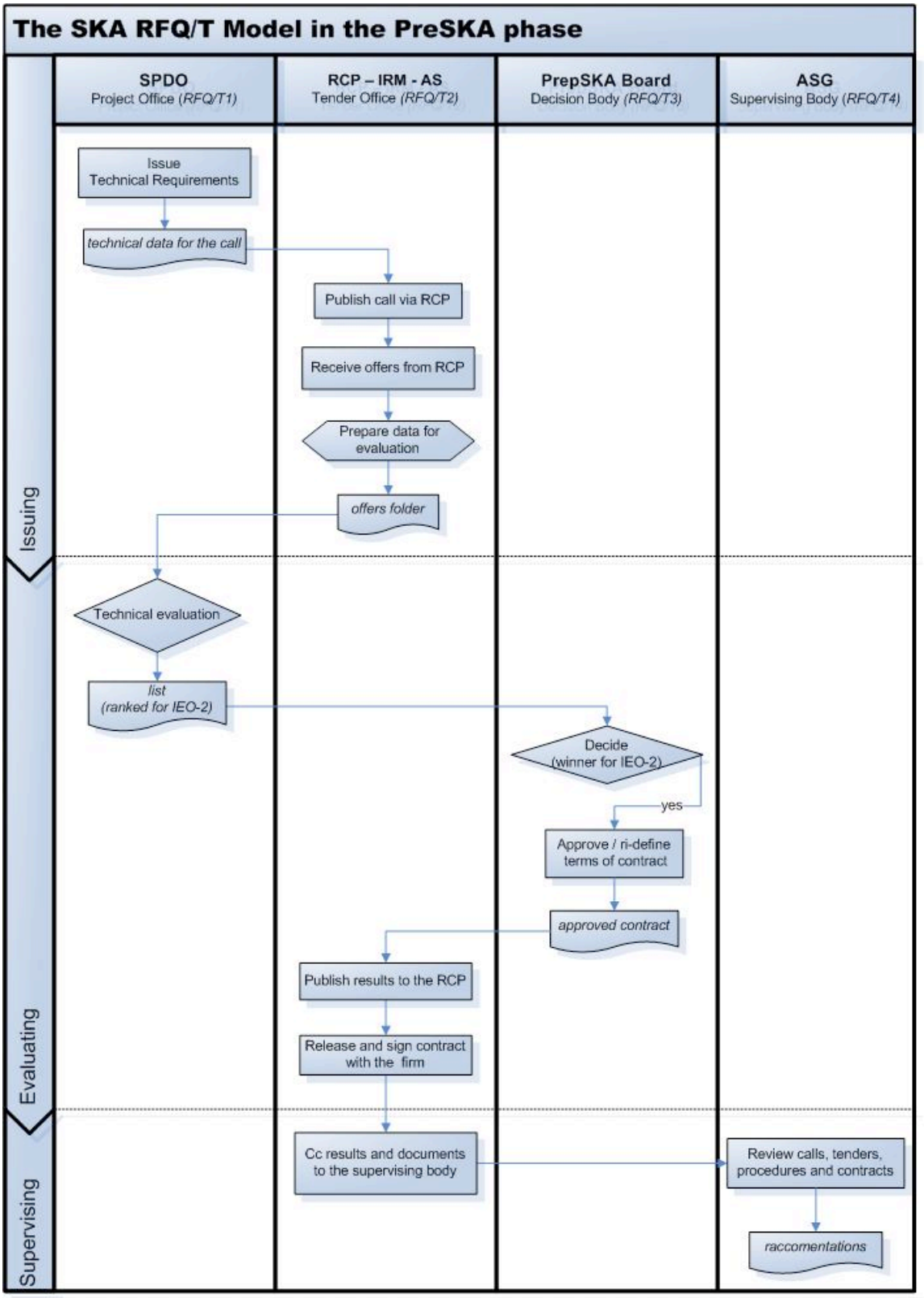
IEO-C. Global price enquiries for COTS requirements

The project office will issue a specification (drafted by the technical domain), and encouraging innovation and emerging technologies. A copy will go to the Regional Industry Contact. The Industrial Relations Manager will manage the receiving of pricing information, and liaise with the technical domain. The PrepSKA board will review pricing activities, and approve if a contract is issued. The ASG will periodically review the procedures and the results.

IEO-D. *'In-kind'* contributions of personnel, tools, technical services, or other resources

Offers of support from industry are generally welcomed as strategic support for the SKA project and with the goal of a win-win outcome. Such approaches must come through the Regional Industry Contacts, and be approved by the PrepSKA Board. All in-kind support of this nature must be transparent to all stakeholders.

Detailed procedures and protocols for all 4 items, as well procurement relating to the production and operational phases, will be delivered to the SKA Project Office by the WP5, after the official approval from the PrepSKA Board.

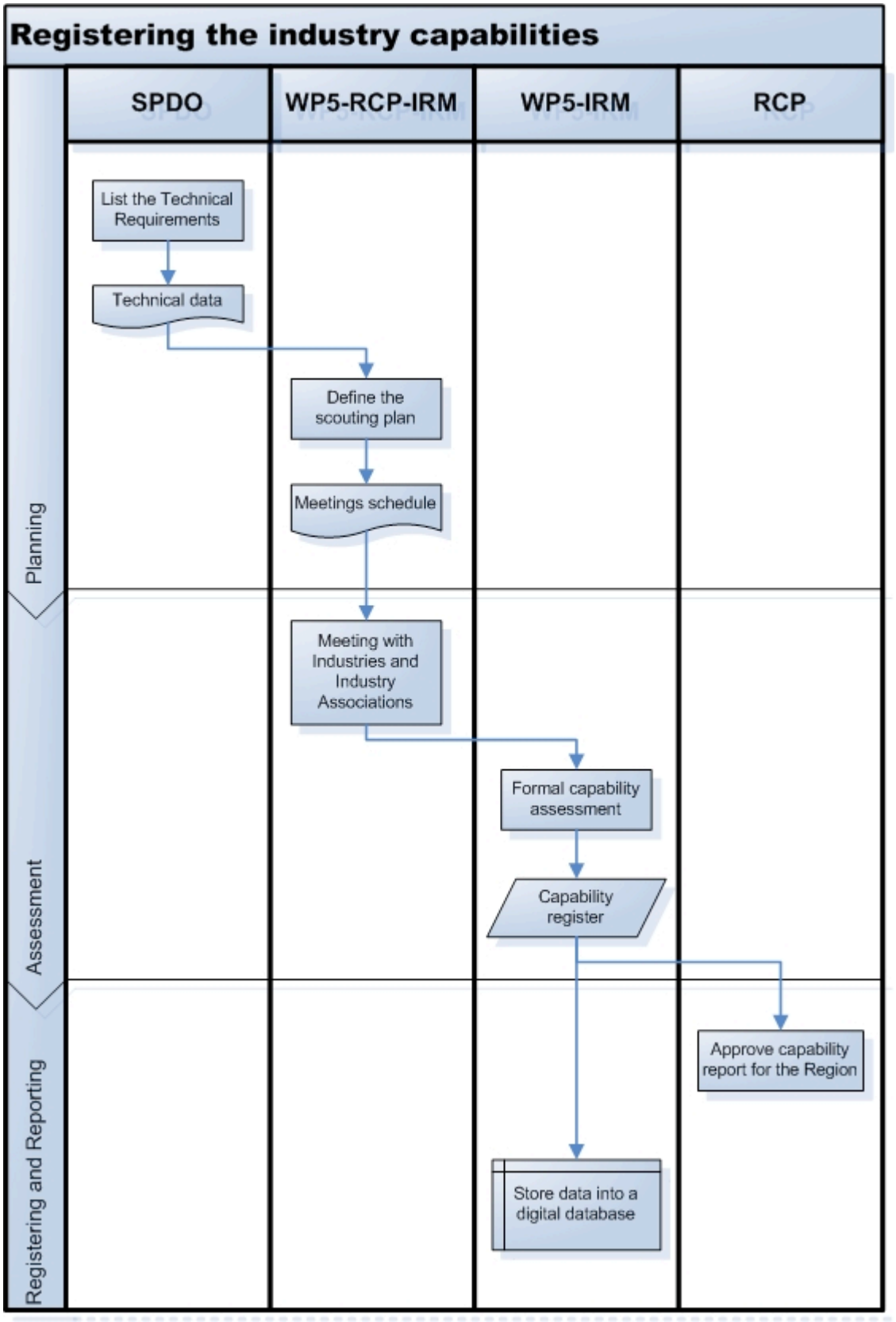


Legend:
SPDO = SKA Project Development Office
RCP = Regional Contact Point
IRM = Industrial Relations Manager
AS = Admnistrative Staff
ASG = Agencies SKA Group

5.2.4 Promoting the industry involvement and registering the industry capabilities

As described by the PrepSKA deliverable 5.2 of the Annex I of the PrepSKA EC contract, the WP5 is supposed to gather information about the industry knowledge in the form of a database addressing the availability of sources for main systems/sub-systems for use in the SKA, capacity/capability of industrial structure, constraints and limits to market accessibility, and legal advice about local/global procurement and IP legislation.

The WP5 PrepSKA funded Manager-Industry Participation Strategy (M-IPS) following a plan provided by the WP5 and approved by the PrepSKA Board, will contact, jointly with the WP5 leader, each Regional Industry Contact person and request them to arrange meetings with key industry firms, groups, Industry Associations etc. Then a team composed by the WP5 leader, the RCP and the M-IPS will execute these meetings by way of a formal capability questionnaire (i.e. medium level audit) provided by WP5/SPDO and return the results to the database. Then a report will be provided back to the regional SKA industry person, and Government industry office. (See diagram below).


Registering the industry capabilities
SPDO
WP5-RCP-IRM
WP5-IRM
RCP
Planning
Assessment
Registering and Reporting
List the Technical Requirements
Technical data
Define the scouting plan
Meetings schedule
Meeting with Industries and Industry Associations
Formal capability assessment
Capability register
Approve capability report for the Region
Store data into a digital database

6. Acronyms

ALMA	Atacama Large Millimetre Array
BTP	Build to Print
CERN	European Organization for Nuclear Research (Organisation Européenne pour la Recherche Nucléaire)
COO	Cost of Ownership
COTS	Commercial off the shelf
DFM	Design for Manufacture
EC	European Community
ELT	Extremely Large Telescope
ESO	European Space Observatory
IP	Intellectual Property
IT	Information Technology
ITER	International Thermonuclear Experimental Reactor
ITP	Integrated Product Teams
LHC	Large Hadron Collider
LOFAR	Low Frequency Array
M-IPS	Manager – Industry Participation Strategy
MOU	Memorandum of Understanding
OBS	Output based Specifications
OEM	Original Equipment Manufacturer
PrepSKA	Preparatory SKA
R & D	Research & Development
RFI	Radio Frequency Interference
RFQ	Request for Quotation
RFT	Request for Tender
SKA	Square Kilometre Array
SPDO	SKA Program Development Office
WBS	Work Breakdown Structure
WLC	Whole Life Costs
WP	Work Package
WTO	World Trade Organisation

End