

Chapter 7

The Sustainable Management of Research Equipment



The critical aspects of a robust management plan includes the: (i) physical infrastructure; (ii) services and utilities; (iii) safety and security; (iv) insurance arrangements; (v) alternate power supply; (vi) maintenance; (vii) access and training; (viii) having appropriately skilled instrument staff in place, and (ix) a clear data management plan (Fig. 7.1). From the aspects highlighted above, the following key areas must

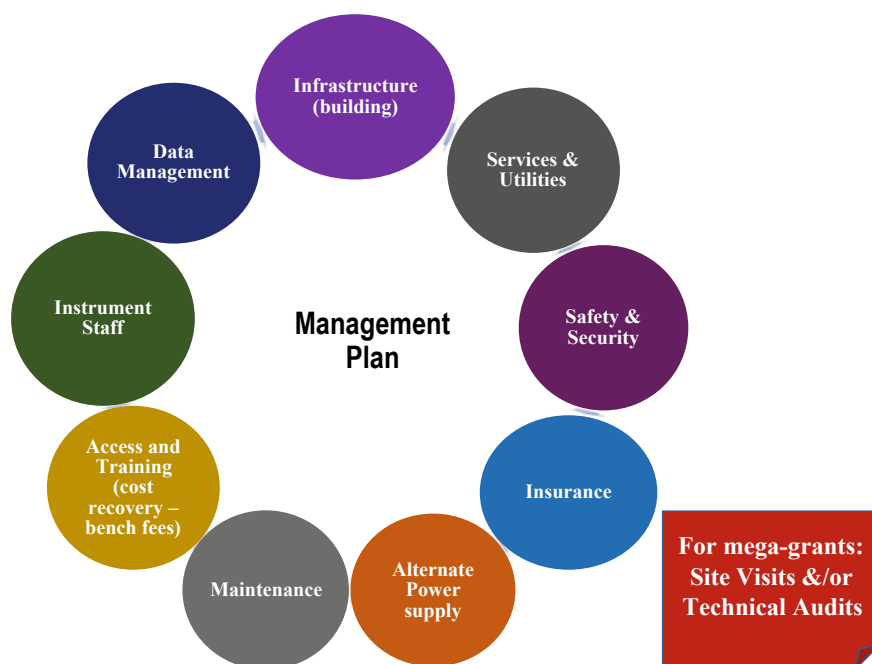


Fig. 7.1 Key elements of a robust management plan (National Research Foundation, 2018b)

be drilled into: (i) human resourcing for attracting, retaining and upskilling appropriately trained and competent instrument staff; (ii) maintenance including services and utilities; (iii) compliance with governance structures; (iv) financial sustainability; (v) optimal utilisation and access to the equipment; (vi) infrastructure to house the research equipment; and (vii) data management (Fig. 7.1). This management plan must be defined and described in detail in partnership with the selected and/or preferred supplier. At all stages herein, the supplier must be duly consulted. In addition, this plan must have a dedicated budget and resources. The best manner in which to address these dimensions of a management plan is through the use of a Gantt chart (refer to Annexure A).

7.1 Human Resourcing

The critical human resource personnel associated with the management and maintenance of RI, as highlighted in Chap. 5, include staff scientists, operators, technicians, engineers and data scientists that are available to operate, manage and maintain state-of-the-art research equipment and the data that is consequently generated from its usage. The human resourcing linked to the effective and sustainable management of research equipment is dependant on the level of skills, experience and track record of the team who manage the equipment. With appropriately skilled and experienced staff appointed the transition time and training needs are minimal, especially, if the institution is able to negotiate with the supplier to train a resident or in-house engineer resulting in efficient operation of the equipment. The ability and experience of skilled staff to fully operate and maintain research equipment further accrues cost and time savings in terms of the training and support requirements from both the institution and supplier. Fundamentally linked to the sustainable management of research equipment is the identification of an academic champion that drives the research programme around the use of the equipment. Staff scientists are able to ensure that the equipment can be utilised to address a multitude of research projects across a number of disciplines that can be supported by the equipment. As much as there is a need to ensure that the appropriately skilled and experienced staff are in place, there is also the need to ensure that there is a plan to transfer these skills and training to the next generation of emerging researchers. Upskilling these researchers will allow for increased usage of the facility which will not only accrue revenue to offset the cost of managing the facility but also contribute to developing the human capital pipeline in an area that is deemed a scarce skill.

7.2 Maintenance of Systems

This section makes specific reference to service level agreements and/or maintenance contracts with the selected supplier and/or manufacturer and includes warranties and guarantees on the system as a whole as well as individual components and parts. In establishing a home for the research equipment, the role of the supplier must not be underestimated. Before the installation of new or upgraded research equipment, related or supporting materials, equipment and reagents must be procured. In addition, it is imperative to have a clear understanding of the full list of services and provisions that are either included, excluded or deemed optional in the contract with the supplier. Defining the type and nature of support includes specifying any special terms and conditions that may be applicable to a specific research equipment and/or its geographical location. Some of the questions that may need to be considered are as follows:

- Will the agreement cover preventative as well as remedial maintenance?
- What is the specified number of preventative and remedial activities scheduled in the contract?
- What software products and services are defined in the agreement?
- Will the scheduled preventative and remedial maintenance include the upgrade of the operating software and services?
- What is the duration of the contractual arrangement?
- What are the supplier's policies for the maintenance and support?
- What is the supplier's standard cover and charges?
- Will the standard cover be sufficient for the grant holder? What are the costs related to extended cover?
- What are the annual increases of inflationary costs that the grant holder and research institution need to plan for?
- Are there limits on parts or labour costs in the agreement?
- Will the machines be serviced by technicians and engineers that are locally based or based at the manufacturer's facility abroad? In the latter case, would the supplier make available replacement equipment to the grant holder?
- What is the maximum turnaround time for resolving system-related challenges if a technician or engineer has to travel from abroad? A major challenge that is faced by countries in the global south is that research equipment is procured from suppliers and/or manufacturers that are usually based in the global north, specifically from the European Union or the United States of America. Hence, if there are problems with a system or if a component is damaged and needs to be replaced, then this query is logged against a global list of queries, leading to a longer equipment down-time resulting in low productivity. This has a cascading effect on research publications and other outputs as well as time needed for completing postgraduate qualifications. The turn-around times to resolve any system challenges must, therefore, be discussed and specified in the contractual arrangement with the supplier. This high impact risk can be minimised to some extent,

by the supplier training a resident or in-house engineer on how to manage and maintain the research equipment.

7.3 Infrastructure to House Research Equipment

The infrastructure required to house the research equipment includes other infrastructural pre-requisites that are essential for the research equipment to be able to function according to its technical specifications. Addressing this dimension requires the manufacturer and/or supplier to co-operate with the researcher and the research institution in evaluating the geo-technical suitability of the geographical site selected to house the system and making recommendations on how best to address environmental challenges. In addition, the manufacturer and/or supplier plays a vital role in specifying and defining the environmental conditions as well as the requirements for constructing a new building or refurbishing an existing building so that the optimal functionality of the system is ensured. Trains, wave motion of the ocean and elevator shafts, to name a few, have all been implicated in some form or the other to either partially or fully impacting on the functionality of the equipment by creating interference to the system. Cancellation/filtering system(s) need to be in place that allow for the functionality of the system to be at its most optimal given the challenges linked to the geographical location of the research equipment. Again, this would require the expertise of the manufacturer and/or supplier in identifying the most appropriate cancellation/filtering system(s).

In addition to the building and geographical location, utilities and services need to be considered when defining the housing requirements for research equipment. This includes putting in place an uninterrupted and backup power supply in case of power failures which may cause unnecessary complications, including short circuiting within critical components of the research equipment at the time of a power surge. This can cause problems relating to the functionalities of certain components of state-of-the-art research equipment such as laser beams which, in turn, can lead to measurement errors, if the equipment is not recalibrated. Other supporting infrastructural requisites may include feeder research equipment being put in place to enhance the operational capacity of the research equipment. For example, a Focused Ion Beam Scanning Electron Microscope (FIBSEM) is an essential pre-requisite feeder research system that would be needed to prepare inorganic, organic and biological samples of a homogenous geometry and thickness. Such homogenous samples would facilitate a more accurate, useful and meaningful sample characterisation and analysis when using the High Resolution Transmission Electron Microscope (HRTEM).

7.4 Access Strategy

An access strategy needs to be defined in order to facilitate open and wide access, which must be driven by excellence as measured by the scientific merit of research proposals that are submitted by current and potential users of the equipment. This includes taking into consideration and planning for private sector usage which in turn can be charged at a premium hourly rate for equipment usage. Access rates can, therefore, be differentiated according to the various categories of users, which include, but is not limited to, the grant holder, students, postdoctoral fellows, intra-institutional collaborators, other researchers and the private sector. Having an access charge-out rate is a necessary tool for the researcher managing the equipment to be able to accrue some revenue that can aid in off-setting some of the cost(s) related to day-to-day operations.

The Food and Agriculture Organisation of the United Nations (1992) has put up guidelines for calculating machine rate, charge-out fee. It recommends that these costs should be classified in terms of fixed, operating and labour costs. All three types of costs need to be considered when determining the minimal charge-out rate for usage of equipment. Fixed costs are those costs that can be traced directly to the usage of the equipment such as depreciation on the research equipment; interest on investment or loan(s); taxes; storage of data; backup systems such as UPS; and insurance (Food and Agriculture Organisation of the United Nations, 1992). In most instances, depreciation is not factored into the calculation of the user rates for researchers as it will significantly inflate the charge-out rate, but depreciation must definitely be considered when calculating commercial rates for the usage of research equipment by the private sector. Operating costs relate to those costs that are incurred from operating the research equipment in order to generate reliable data. These costs include computer costs; software licences; service and maintenance contracts; consumables (including direct and indirect materials and supplies); rental costs for the space where the equipment is placed; utilities such as electricity and water; equipment maintenance; and repairs (Food and Agriculture Organisation of the United Nations, 1992). Labour costs are those costs that are associated with the employment of the staff that manage and maintain the research equipment. It directly links to the proportionate salary of these staff members, spent on a project, including benefits linked to their salary packages such as medical aid and pension fund, amongst others (Food and Agriculture Organisation of the United Nations, 1992). Collectively, these three types of costs can be converted into an hourly rate that will then be used as the minimal charge-out rate for accessing and using the research equipment. The formula utilised to calculate charge-out rates differ across the various types of research institutions and countries. Hence it best to solicit the advice and expertise of a financial or asset manager in calculating an appropriate charge-out rate.

7.5 Data Management and Its Preservation

This section reflects on the management and preservation of the four “Vs” of data, viz. (i) volume; (ii) variety; (iii) velocity; and (iv) veracity (Hey, Tansley, & Tolle, 2009). The section links to the specialist skills, as described in Chap. 5, required to navigate this niche area. Data management and its preservation is essential to the long-term sustainability of research equipment. Data management relates to the management of information through its lifecycle from creation and storage to it becoming obsolete, at which stage information is deleted. Advanced technologies, along with data intensive research, are multiplying the volumes of data in all scientific disciplines. In addition, the increase in data generation stems from billions of people using digital and smart devices and social media services from research, digitised literature and archives to public services at hospitals and land registries (European Commission, 2016). Big data sets and their management is no longer an issue that relates to data intensive disciplines but has become an everyday challenge in many areas of life. Therefore, the administration and governance of large volumes of both structured and unstructured data, which may involve terabytes or even petabytes of information, need to be understood across various dimensions. This is imperative for ensuring the translation of open science into open innovation that creates value by addressing societal needs.

The research data management lifecycle comprises of data (i) creation; (ii) processing; (iii) analysing; (iv) preserving; (v) access; and (vi) re-use (University of Essex, 2017). Efforts must be undertaken to develop the necessary digital infrastructures for data generation and dissemination, for storage and analysis with the objective of ensuring that the ideal conditions are met for the undertaking of excellent research (European Commission, 2016).

The creation of data usually entails: describing the research design, data management plan (format, storage, security and consent for sharing), locating existing data, collecting data, and capturing and creating metadata. Data processing includes transcribing, translating, digitising, validating, anonymising, describing, managing and storing data. Data analysis refers to the interpretation and derivation of data, as well as the preparation of data for its preservation and storage. A product of this phase of the research data management lifecycle is the generation of research outputs such as publications. Data preservation requires the migration of data to the best format in a suitable medium where it can be backed-up and stored. Integrally linked to data preservation is the creation of metadata and documentation as well as the archiving of data. Once the above phases of the data management lifecycle have been addressed, measures must be adopted for ensuring researcher access and re-use of the data. The former requires the distribution, sharing, promotion, controlled access and establishment copyrights to the data. The latter entails undertaking research reviews, follow-up research, new research, and usage for the purpose of teaching and learning (University of Essex, 2017). The decision to either preserve or dispose of data ought to be made up front during the planning stage. If data is to be preserved then it must be stored with a clear open access policy that adheres to specific traceability as well

as national, social, economic and regulatory arrangements (Organisation for Economic Co-operation and Development, 2007). In accessing data, the concept of data citation gains increasing relevance, which is the practice of providing a reference to data in the same way as researchers provide a bibliographic references to research publications (Corti, van den Eynden, Bishop, & Woollard, 2014).

The access to data accrues the following benefits: (i) increases the returns from public investment in research; (ii) reinforces open scientific inquiry; (iii) encourages diversity of studies and opinions; (iv) promotes new areas of research; and (v) enables the exploration of topics not envisaged or thought possible by the original researchers (Organisation for Economic Co-operation and Development, 2007). Open access to research data from public funding should be easy, timely, user-friendly and preferably internationally available in a transparent manner, ideally via the internet. The European Cloud Initiative advocates for the sharing of data and developing a trusted open environment for storing, sharing and reusing scientific data and results (European Commission, 2016).

Access may only be restricted or limited in the following instances relating to (i) national security; (ii) privacy and confidentiality relating to the data on human subjects and other personal data; (iii) trade secrets and intellectual property rights, usually derived from engagement(s) with private enterprise; (iv) protection of rare, threatened or endangered species; and (v) data under consideration in legal action(s) (Organisation for Economic Co-operation and Development, 2007). If data is to be disposed then files should be deleted after they have fulfilled their purpose.

The research data management lifecycle achieves increasing levels of complexity when large data volumes are involved. Large data volumes are synonymous with big data commonly associated with the usage of dedicated large research infrastructure facilities, such as GRIs, that require multinational investments and are utilised by large collaborative networks (Bicarregui et al., 2013). One of the key challenges in managing big data includes the undisciplined and unstructured manner in which disparate data is generated, mined and managed by a variety of independent researchers. Such anarchy requires a governmental and inter-governmental policy framework to guide the generation, preservation, storage, access and re-use of large data volumes (Bicarregui et al., 2013). Such a policy framework would also address key issues such as (i) ownership of data; (ii) open data; (iii) disposal of data; (iv) data mining; (v) data security, amongst others. Ownership is a rather sensitive topic—in a number of instances, where the research was funded with public funds. The common practice by public funders is to ensure, through the Conditions of Grant, that scientific data is made universally available for research purposes. This practice of open access aims to improve and maximise access to and re-use of research data, including its verification. Linked to general data release is an ethical dilemma which must be explicitly defined along with mitigation steps in a policy framework. The ethical dilemma links to the process of data mining, otherwise termed knowledge discovery in databases, which forms part of the knowledge discovery process. Data mining relates to the extraction of potentially useful, yet unidentified, information from large volumes of data that reside in different databases (Singh & Swaroop, 2013). This is particularly useful in research relating to national defence and security initiatives.

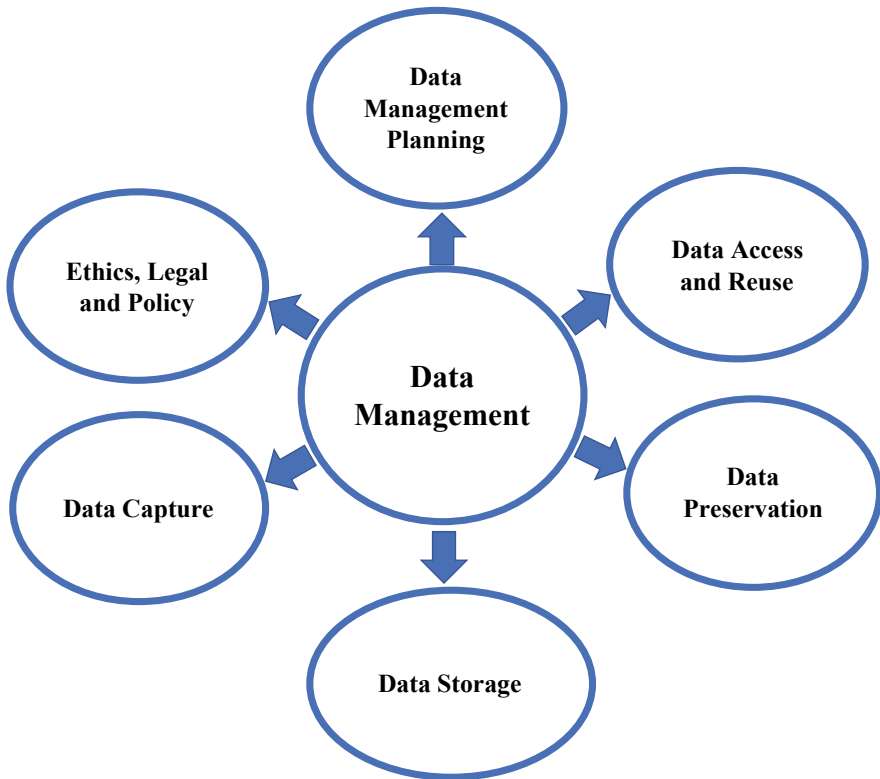


Fig. 7.2 Summary of data management lifecycle

The challenge that arises when personal and/or sensitive data is accessed for analysis and publication as this violates the privacy of individuals whose data is referred to. Methodological and/or statistical approaches must, therefore, be employed to ensure privacy and security of personal information in the data mining process (Singh & Swaroop, 2013) (Fig. 7.2).

7.6 Financial Management

Financial management takes into consideration the full cost(s) relating to the management of the equipment over its lifespan, including its exit strategy. Revenue streams, which includes, but is not limited to access rates, need to be explored and properly planned to ensure that the cost of the daily operations linked to the equipment is affordable to the researcher, the department and the research institution. Financial resources are the primary drivers for a well-managed and sustainable equipment management plan—it is the critical enabler for ensuring timeous delivery relating to

(i) buildings and refurbishments; (ii) procuring equipment; (iii) forward cover and other insurance related matters; (iv) service contracts; (v) utilities; (vi) consumables; (vii) software upgrades; (viii) data management; (ix) staffing costs; and (x) logistics and administration. An efficient financial system and administrator would (i) ensure that accounts are in order; (ii) facilitate the collection of late payment of invoices; and (iii) manage other administrative issues such as contacting service engineers, tracking the duration of service contracts, amongst others.

Essential to this process is defining in detail the specifications of the research equipment or system that the researcher would want to procure that meets their research needs. This is a precautionary measure that would close any gaps relating to any hidden costs that may need to be covered by the researcher or the institution at a later stage due to ambiguity or a lack of clarity. Specifying the capabilities, peripheral system and other components of the research equipment must be driven by the research need(s). It is not simply a matter of a single research system servicing the needs of a diverse group of researchers, as is the case with many instruments that are placed in central analytical facilities. The challenge of specifying the requirements of a research equipment is that it must cater for the specific research needs of the researcher. The more specialised the equipment the less likely it is to address a multi-disciplinarily focus. An example is that of a Transmission Electron Microscope (TEM) that is optimally designed to address the research needs of materials scientists which includes a high accelerating voltage electron beam in order to preserve the rather fragile material. Such a system is unable to optimally cater for the needs of biologists that require a cryo-chamber and a lower voltage electron beam. Hence, in order to address the very diverse research needs of both disciplines, hybrid systems would need to be specified and subsequently developed. This hybrid system will not optimally benefit research in either discipline as the discipline-specific specifications on the system will always have to be comprised in order to cater for the research needs of the other discipline(s). Such sub-optimal hybrid system specifications hinder to some degree the discipline-specific process of scientific inquiry.

Consideration must therefore be afforded to both the immediate and possible future projects that can be undertaken utilising the research system. This implies that the specifications of the research equipment must lend itself to include possible upgrades at a later stage that would cater for the researcher's evolving research needs. Caution must be employed to ensure that a "wish list" is not put forth that goes beyond the researcher's immediate and foreseeable needs, expertise and skills set. In sourcing the best price, it is best to consider either going on an open tender to solicit the best supplier (vendor) or to at least obtain three competitive written quotations for the system that the researcher has fully specified. Against the backdrop of good governance and transparency, a supply chain processes (SCM) must be undertaken. The processes and methods of procurement are summarised in Table 7.1 which is extracted from the Public Finance Management Act (South African Department of Finance, 1999).

In many instances, the procurement of research equipment requires the employment of competitive bid processes, as the costs tend to exceed R500,000. This therefore means that the following committees would need to be constituted:

Table 7.1 Procurement method to be employed per monetary threshold

Monetary threshold values for goods, services, and works	
Value	Procurement method
R0 to R2000 per case (VAT included)	<ul style="list-style-type: none"> Follow the petty cash procedure noted in the supply chain management (SCM) policy No capital assets, consultants or items available on contract may be purchased through petty cash
R0 to R10,000 per case (VAT included)	<ul style="list-style-type: none"> Follow the minimum three “verbal or written quotation” process Official order should be placed against a written quote from the service provider
Above R10,000 to less than R30,000 per case (VAT included)	<ul style="list-style-type: none"> Follow the minimum three “written quotation” process No need to apply the preferential procurement policy framework management act (PPPFA)
R30,000 to R500,000 per case (VAT included)	<ul style="list-style-type: none"> Follow the minimum three “written quotation” process Apply the PPPFA and the 80/20 principle For all procurement greater than R30,000, obtain a valid tax clearance certificate from the service provider
Above R500,000 per case (VAT included)	<ul style="list-style-type: none"> Follow the competitive bidding process Apply the PPPFA and the 90/10 principle

Source South African Department of National Treasury (2000)

- Bid Specification Committee (BSC):** Constitutes a group of technical experts that have experience using the same and/or similar research equipment. This committee must include a supply chain practitioner. The fundamental responsibility of the BSC is to compile the specifications for the type of research that would benefit from the procurement and placement of the research equipment. Included in the specifications is a scorecard that defines the evaluation dimensions against which potential service providers/vendors will be measured. Once the specifications and scorecard have been defined, a process of open solicitation of proposals and written quotations is undertaken using various media, such as newspapers, online advertisements, amongst others (South African Department of Finance, 1999).
- Bid Evaluation Committee (BEC):** Constitutes a group of individuals that will evaluate all the solicited proposals and quotations against the specifications and scorecard that were defined by the BSC. This committee must include a supply chain practitioner. This committee may comprise a maximum of two representatives from the BSC. The responsibility of the BEC is to recommend to the Bid Adjudication Committee the service provider/vendor that offers the best value for money after all relevant factors, including cost, have been considered (South African Department of Finance, 1999).

- **Bid Adjudication Committee (BAC):** usually comprises the Chief Financial Officer from the research institution as chairperson of the committee, as well as other nominated senior officials, including a supply chain practitioner. This is an independent committee that is composed of different members from those serving on the BSC and BEC to ensure a fair and transparent process. The task of this committee is to consider the (i) processes undertaken to solicit proposals and quotations in line with the SCM policies and procedures; and (ii) consider the recommendation of the BEC, prior to making the final award (South African Department of Finance, 1999).

A summary of the SCM processes is presented in Fig. 7.3. At any stage, should a conflict of interest be recognised and/or declared, then that conflicted member would need to recuse themselves from a sitting committee.

Once a supplier has been identified in line with the institution’s SCM processes, the *negotiation of the terms and conditions of the service contract* for the research equipment commences. This contract would ultimately be signed off by the management staff at both the research institution and supplier’s and/or manufacturer’s offices. In the South African context, it has been found that research institutions face numerous challenges in managing service contracts with suppliers of research equipment. The key is not to sign the standard service contract template but to consider customising the contract to meet the needs of the research institution and the

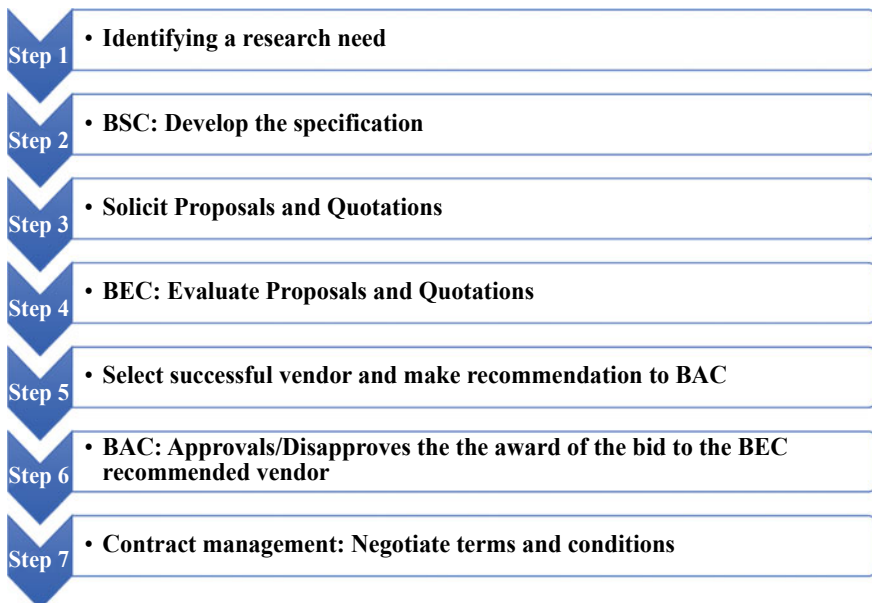


Fig. 7.3 Summary of the SCM processes

skills level(s) of the researchers and staff managing and maintaining the research equipment at a specific institution.

This would then inform the nature of the level of hands-on support and training required from the supplier as well as their response time to any query or instrument malfunction. Hence, clear roles, responsibilities and turn-around times need to be clearly articulated within the service agreement. When parties enter into an agreement they have to determine the costs related to the provision of services over and above that which accompanies a standard contract. One should never assume that the amount mentioned in the contract is correct even if it was done by the procurement or finance office—it is always recommended to check for errors, especially where formulae and equations are used and detailed.

The following should be considered when negotiating a service level agreement or maintenance contract with a supplier:

- The parties need to determine the time intervals at which costs are calculated, for example hourly/weekly or monthly basis.
- Is the costed amount inclusive or exclusive of VAT?
- What happens when overtime is worked by supplier staff in resolving issues with the research equipment?
- What currency will be applicable? Currency exchange rate may have to be considered.
- The parties also need to agree on invoicing, payment terms, interest on late payments and increases in price (is it a fixed annual increase or an increase linked to the Consumer Price Index?).
- Make sure interest is correctly stated in the contract as per agreement between the parties, i.e. compound, fixed or simple.
- Ensure ALL costs are covered.
- Ensure that the agreement complies with all applicable legislation, e.g. South African Revenue Service (SARS), National Credit Act (NCA), Consumer Protection Act (CPA), etc.
- Penalty clauses for non-performance by the supplier and/or manufacturer.

Table 7.2 presents an overview of the contracting process.

It is, therefore, important to understand the basic rules of the contractual arrangement between the research institution and the supplier/manufacturer before entering into one—the content must be correct and the researcher must be satisfied with the terms and conditions before it is signed. Ultimately a contract is legally binding.

Key to the whole service contract is understanding the difference between the warranty and guarantee of part(s) and/or component(s). A warranty generally refers to an assurance that if the product does not work as is claimed it will be corrected either by repair or replacement of the product within a specific period by the supplier and/or manufacturer void of a refund.

- Many products come with a warranty promising repair or replacement of parts, inclusive of labour, for months, years or life, as defined by the duration of the contract. In theory one can return a product to the supplier for repair but most research equipment suppliers are local distributors of products manufactured elsewhere. It

Table 7.2 Step by step guide to contracting

Step 1	Step 2	Step 3
Set out the contractual purpose, aims and objectives <ul style="list-style-type: none"> • This should form the basis for the contract preamble • Once the objectives are defined it will determine the contract type and contract name • Consider everything and align with subject matter 	Sketch the contract outline; include a list of required and suggested clauses <ul style="list-style-type: none"> • Look for similar type contracts or precedents for comparison • Make sure there is no company standard • Get feedback from the person who negotiated the contract, compare notes and make sure you are both on the same page 	Draft and flesh out the contract; consider each clause <ul style="list-style-type: none"> • Ensure that each clause fits the contract and won't bite you later • Once again conduct risk assessment, ensure equal balance and fairness • If the agreement is a product of an awarded bid make sure the contract and the accepted bid is aligned

Source Mahlangu (2010)

must, therefore, be ascertained if a faulty product is to be sent to the manufacturer's facility abroad for repair and/or replacement (Mahlangu, 2010).

- An implied warranty is one that arises from the nature of the transaction and the inherent understanding by the buyer rather than from the express representation of the supplier (Mahlangu, 2010).
- The warranty of merchantability is implied, unless expressly disclaimed by name, or the sale is identified with the phrase "as is" or "with all faults" or "Voetstoots". To be "merchantable" the goods must reasonably conform to an ordinary buyer's expectation, i.e. they are what they say they are (Mahlangu, 2010).

A guarantee is a promise assuring that certain conditions will be fulfilled and may or may not have a time limit attached. The original price or consideration paid for the contract will be returned or the product will be replaced (Mahlangu, 2010).

7.7 Summary

The scientific case must justify the need for a specific research equipment. Once such a case has been presented and approved for funding, financial processes and procedures must be employed that adhere to national legislation, which is the PFMA, in South Africa.

The identification of a suitable supplier and/or manufacturer must follow a competitive SCM process. The appointed supplier and/or manufacture must enter into a contractual arrangement either through a service level agreement or a maintenance contract with the research institution. This agreement must be tailored to address training needs, preventative and remedial schedules, time-frames, warranties and guarantees.

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