Delivering a radiation protection dividend: systemic capacity-building for the Radiation Safety Profession in Africa

Julian Hilton[1]**, Brian Birky**[2]**, Mahmoud Hejazy**[3]**, Malika Moussaid**[1]
1. Aleff Group, 53-54 Skylines, Limeharbour, London, E14 9TS, UK
2. Florida Industrial and Phosphate Research Institute, 1855 W. Main St., Bartow, FL 33830, USA
3. Radiation Oncology Victoria, Epping Medical and Specialist Center, 230 Cooper Street, Epping, Vic 3076, Melbourne, Australia

Abstract
Many African countries planning to enter the nuclear energy "family" have little or no experience of meeting associated radiation safety demands, whether operational or regulatory. Uses of radiation in medicine in the continent, whether for diagnostic or clinical purposes, are rapidly growing while the costs of equipment, and hence of access to services, are falling fast. In consequence, many patients and healthcare workers are facing a wide array of unfamiliar challenges, both operational and ethical, without any formal regulatory or professional framework for managing them safely. This, combined with heighted awareness of safety issues post Fukushima, means the already intense pressure on radiation safety professionals in such domains as NORM industries and security threatens to reach breaking point. A systematic competency-based capacity-building programme for RP professionals in Africa is required (Resolution of the Third Afrirpa Regional Conference, Nairobi, September 2010). The goal is to meet recruitment and HR needs in the rapidly emerging radiation safety sector, while also addressing stakeholder concerns in respect of promoting and meeting professional and ethical standards. The desired outcome is an RP "dividend" to society as a whole. A curriculum model is presented, aligned to safety procedures and best practices such as Safety Integrity Level and Layer of Protection analysis; it emphasises proactive risk communication both with direct and indirect stakeholders; and it outlines disciplinary options and procedures for managers and responsible persons for dealing with unsafe or dangerous behaviour at work. This paper reports on progress to date. It presents a five-tier development pathway starting from a generic foundation course, suitable for all RP professionals, accompanied by specialist courses by domain, activity or industry. Delivery options are discussed. Part of the content has already been developed and delivered as MiLoRAD, based on extensive experience training radiation safety personnel in the United States.

Key Words: capacity-building; safety culture, competency

Introduction
The closing resolutions of the Third African IRPA Regional Congress, Nairobi, Kenya, September 17, 2010 addressed the need for: "developing National/Regional Strategies and Infrastructures for Radiation Protection (RP) and fostering Co-operation and Networking among RP Professionals in Africa". [1] It was recognised that achieving this goal would require a number of actions including: 1. " [efforts] to promote professional standards of training and practice among Radiation Protection Professionals in Africa and to found and foster Radiation Protection Societies or Associations at National and Regional levels" (Resolution 1) and 2. "the promotion of formal [and informal] networks, drawing on existing infrastructures and training opportunities that are available in the region" (Resolution 2)

One of the vehicles adopted for pursuing these objectives was "The blueprint for action in respect of systematic capability building and training in RP" (Resolution 4). [2] That blueprint was anchored in the competency-based approach to training and capacity building, an approach presented earlier in 2010 to the NORM VI conference in Marrakech [3]. It was agreed in Nairobi that a progress report on capacity-building would be given both at this meeting, IRPA 13, and AFRIRPA 4, Morocco, 2014.

So here is the report. As Charles Dickens might have written, it is a tale of two narratives – good news and bad news. At the level of individual training and capacity building activities, much has been done, and more is in prospect; and the activities that have been undertaken are increasingly clearly aligned with economic and social needs on the ground. But at the level of systemic development of a radiation protection profession across the region with a distinct regional identity very little progress has been made. Why such an outcome? The answer may in part lie within the RP community itself. If it can use

a competency-based approach to become less tribal in nature it will become much easier to achieve systemic progress.

1. Building and Sustaining Capability: The Competency-based Approach to the Culture of Safety

Competency-based training (CBT) is a systematic, knowledge and skills-based approach to vocational education and training that focuses on what a person can do in the workplace as a result of completing a program of job- or task-specific training. It is the first step in a three part process: as competency develops in an organisation and as specific skills are combined into individual and team work behaviours, so an organisation builds capacity. And when capacity is exercised in a real-world working environment the outcome is capability. Hence the simple "three C" equation: Competency + Capacity = Capability. The consequences of this equation are shown in Fig. 1:

Competency + Capacity = Capability
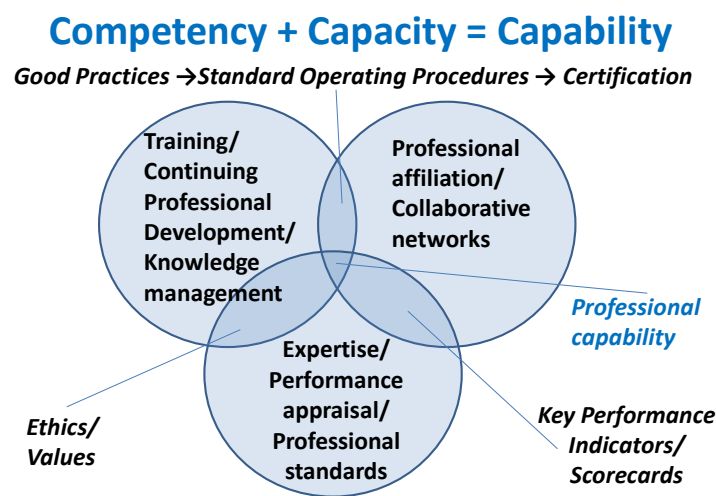*Good Practices →Standard Operating Procedures → Certification*

Fig. 1 Building Capability

A competency may defined in terms of what a person is required to do (operational task), under what conditions it is to be done (operating conditions), what the task is intended to achieve (outputs and outcomes) and how well it is to be done (performance standards). Competencies commonly map to skills, which in turn may be simple or complex in nature. As such skills aggregate, so capacity is engendered and internalised. This process is essential in maintaining a culture of safety.

Competencies may be broken out into different categories, such "essential" and "universal" or "global". An essential competency is one that is so critical for a particular job that that job cannot be performed without it. A "universal" competency is one that is required of all members of staff in an organisation, regardless of job title. An example of a universal competency might be understanding of and compliance with the organisation's mission, as for example the culture of safety. In many workplaces too much emphasis is placed on "hard" scientific, technical and mechanical skills, at the expense of "soft" skills, such as team work communications. Many essential skills are "combined" in nature, such as life-cycle analysis of the performance of a production process. Safety is the outcome of applying many skills, the result of making safety culture integral to organisational capability – to the extent that an organisation is dysfunctional if it behaves in a systemically unsafe way.

Building organisational capability requires the development and transmission of institutional expertise. One of the most seminal competency models that achieves such transmission was that developed in response to the 1980s pursuit of machine intelligence. [4] This broke competency out into a five-tiered, progressive learning model, as follows: 1. Novice → 2. Advanced Beginner →

3. Competent → 4. Proficient → 5. Expert. The resulting system is pragmatic (i.e. skills are linked to particular jobs), progressively transferable, (i.e. those skills roll up into more responsible jobs as the employee moves higher in the organisation, and "learner-centred" or "learner-driven", meaning the learner has the freedom to learn at will, but also the responsibility to do so as part of an underlying ethical commitment to safe work. So the learner can move up the skill and safety culture pyramid in discrete steps. Competency-based approaches to radiation safety training in general are starting to attract attention at government level. [5] So how can it be used system wide in the African region and how can it be scaled to the various industry sectors which depend on it?

2.   The Blueprint: A Pathway to Preparedness

Based on progress to date since the AFRIRPA meeting the original 12 point capacity-building blueprint has consolidated naturally into an 8 point version as certain points have already been met, such as having a mandate from stakeholders to proceed. The blueprint consolidates into a pathway as follows:

2.1. Needs and vision
Capacity-building in the African radiation safety arena requires a systematic effort to strengthen and sustain the professional Radiation Protection community at both national and regional levels. This systematic effort is based on the formula identified above - "competency + capacity = capability". The vision is to foster a strong, competent and well-respected radiation safety profession, resulting in:

- Sustained on-demand RP capability at both national and regional levels
- An overall operational culture of safety leading to stakeholder confidence
- Sustained protection of occupational, public and environmental health and safety
- A positive and continuous societal RP dividend supporting economic development.

2.2. Health, safety and environment (HSE)
While there are clearly highly specific safety issues associated with radiation protection, it is proposed that the approach taken be aligned to current state of the art and good practice in respect of Health, Safety and Environment in industry in general. [6] [7] [8] This brings with it requirements such as the pursuit of a culture of safety based on the application of principles such as Hazard Analysis and Critical Control Points (HACCP), and the use of procedures and best practices such as Safety Integrity Level (SIL) and Layer of Protection (LOP) analysis. With a view to reinforcing accountability within a culture of safety, it also requires clear commitment to innovative, non-threatening techniques such as Positive Performance Measures, (PPM) but also to enforceable disciplinary options and procedures for managers and responsible persons in organisations for dealing with unsafe or dangerous behaviour at work.

2.3. Current state analysis
Worldwide, more than sixty countries are now planning to enter the nuclear energy "family" many with little or no operational experience of meeting radiation safety demands, whether from an operational or regulatory point of view. This means the already intense pressure on radiation safety professionals in such domains as medicine, NORM industries, and security threatens to reach breaking point as new demands are made. The situation in Africa is especially acute in this respect. The gap between industrial activity requiring professional RP input and the capacity to support that input from the regulatory and good practice point of view is currently widening, a damaging trend that must be reversed.

2.4 A networked community
Rapid advances in the power of information and communications technologies accompanied by dramatic increases in affordability and accessibility mean that a key strategy for the strengthening of the RP community lies with the use of ICT to build a virtual or networked community. A networked community may be defined as an organisation distributed geographically and whose work is

coordinated through electronic communications. Such communities have a number of distinctive characteristics, such as:

- gaining authority not from a hierarchy but from the peer-reviewed knowledge and skill of their members
- linking people and teams across conventional boundaries (e.g. departments and geographies)
- having members and structures that adapt to changing circumstances
- a culture where management is a sense of mutual responsibility rather than following orders
- exploring innovative ways to work effectively rather than simply following pre-defined processes
- a capacity to readjust or disband teams as needed.

Successful networks exhibit characteristics of innovation, resilience, and self-management.

2.5. Infrastructure and support
Adopting a networked community model already significantly contributes to mending deficiencies in the virtual realm, with cross-over benefits into both field and laboratory settings. These are low-cost, low-barrier options which should be given priority in early-stage capacity building. The same technology platforms will also allow access to scarce or particular forms of knowledge and expertise, though not always in real time, and facilitate mentoring and colleague support.

2.6. The learner-centred adaptable curriculum
Following a learner-centred approach, but also to encourage RP professionals to see themselves as part of a single RP community rather than "tribalised" into discrete disciplines, an outline basic curriculum design is proposed consisting of :

1. A "horizontal" layer – a generic foundation course for all RP professionals; and
2. Various "vertical" layers by industry or key area (e.g. medicine, energy, NORM industry etc) but with common competencies such as communications and team-work.

A draft design for a two-day foundation course has been developed as follows:

DAY 1	DAY 2
Start: Optional Pretest	**Session 5:** Radiation Biology
Session 1: Radiation Safety: Industries and Activities	**Session 6:** Determining, recording and reporting dose
Sessions 2 and 3: Fundamental Knowledge and Core Competencies	**End of Day:** Post test
Session 4: Instrumentation	
Practical: 1. Identify the appropriate survey meter for the application; 2. identify things to verify before performing a survey; 3. perform a survey; 4. report and conclusions.	
Evening clinic: Confidential session review with tutors and students - site- or company-specific radiation safety issues	

Three-day industry specific courses are associated with the two-day foundation programme, supported by the online resources of the MiLo*rad* website, which also includes checklists, scorecards, job descriptions, key terms/ definitions, and references. As a first pilot test for the model consisting of a one-day "hybrid" course built from part of the proposed foundation course, and combined with an introduction to safety in NORM industries, focused on uranium mining and extraction was given at the well-attended International Atomic Energy Agency (IAEA) Regional Workshop, Marrakech, Oct. 31 – Nov. 4, 2011. The feedback was strong in regard to the curriculum content, the capacity-building blueprint and the competency-based approach. Two contextual factors were singled out as having added considerable value: 1. the ability the course gave the participants to interact with the experts presenting, both formally and informally; 2. the support provided to the meeting by the local professional associations, in this case the Moroccan Association of Nuclear Engineers (AIGAM). Such associations provide the supportive framework for a sustainable RP culture.

2.7. Capability through competency benchmarks: certification (input) and performance indicators (outcomes)

Achieving and sustaining capability according to the 3Cs equation can be monitored by one key input measure and by a combination of lead and lag outcomes measures. The key input measure is the extent to which trained personnel achieve and maintain certification in RP. The IAEA 2001 Safety Guide, **Building Competence in Radiation Protection and the Safe Use of Radiation Sources**, refers to the option of assessing trainees and issuing a qualification, but it does not refer explicitly to certification. [9] In the light of experience gained in the safety arena across a range of industries since 2001, it is advisable to require formal certification of any employee in a position of responsibility, most notably "authorised persons" and those in supervisory or managerial positions. This requirement may be set as either a pre-condition of employment or as a time-bound outcome of in-post training. In respect of accreditation, the Safety Guide is more explicit in respect of training centres: "3.14. It may be appropriate and convenient for the regulatory body to recognize certain training centres and courses for their quality and suitability. Such recognition can be formally conferred by a process of accreditation". Again, in the light of experience it may be appropriate now to strengthen this requirement for accreditation to make it mandatory, but with the obvious corollary that the necessary resources must be provided to allow a suitable accreditation process to be conducted and to sustain the performance and quality levels expected of that training centre.

2.7.1. Performance indicators

One means for assessing progress in capacity-building in general, and in the specific execution of roles and responsibilities in the strengthening the RP profession as a whole is the use of key performance indicators (KPIs). The historical tendency has been to favour lagging performance indicators (see Table 1) where the working culture has assigned the ownership of organisational performance to supervisors and managers. Changes in attitude, some forced on managers by failures in the lagging indicator systems, have led to a growth of interest in leading indicators and the promotion of a more proactive approach to a culture of safety which focuses very strongly on training, knowledge and experience, organisation wide (see Table 2). The two models are not in conflict: a combination of top-down and bottom-up measures is likely to lead to a more sustainable safety culture and one that is derived from good practices in the work place rather than imposed from outside.

Safety Outcomes Monitoring: Using Lagging Indicators	Advantages	Disadvantages

• Training and supervision
• SOP compliance/ documentation/ records
• Incidents and accidents
• Vacant posts
• Violations
• Prosecutions
• Dose limits/ reductions
• Lost time injury:
    • frequency rate
    • severity rate
    • lost days.
	• Motivate management
	• An accepted standard
	• Long history of use
	• Used by government agencies, industry associations
	• Easy to calculate
	• Indicate trends in performance
	• Good for self-comparison
		• Reactive
		• Easily manipulated
		• May be biased (management attitude to restricted work, doctor influence/worker attitude to light duties/compensation system/safety awards and competitions)
		• Figures measured are typically low making it difficult to establish trends
		• Managers/safety specialists tend to attribute incidents as one-off or freak event rather than symptomatic of failings in the culture of safety

Table 1: Safety Outcomes Monitoring Using Lagging Indicators

While lagging indicators have much value, organisations increasingly recognise that there is no single reliable measure of health and safety performance, least of all one that measures in retrospect only. What is required is a basket of measures or a balanced scorecard providing both proactive and reactive means to promote an overall culture of safety among both employees and contractors. Accordingly, an alternative, or better, a complementary approach to the use of lagging indicators, is the use of leading indicators or Positive Performance Measure (PPMs). PPMs are a proactive means of achieving effective risk management and safety. Measurement of PPMs provides information on how the system operates in practice, identifies areas where remedial action may be required, provides a basis for continuous improvement and offers a routine channel for feedback and motivation.

Safety Outcomes Monitoring: Using Positive (Leading) Performance Indicators	
Results	**Outcomes**

• Track
     o Reported performance % on a monthly basis by area/department
     o Key incidents
• Anticipate emerging needs
• Evaluate under-performance
     o By incident
     o By trend
	• Review progress at monthly senior management meetings.
	• Target areas for improvement.
	• Intervene through
	     o Training
	     o Enhanced supervision
	     o Disciplinary measures

Objective	**Indicator**	**Measure/ Monitor (by area and by enterprise)**
All activities to be subject to hazard analysis and risk assessment	Risk Assessment	% Risk assessment complete % Control measures implemented
Standard Operating Procedures (SOPs) in place for critical activities	SOPs in use	% SOPs complete in compliant manner
Provision of safe place of work	Monthly work place inspection target for all frontline supervisors across whole site and by specific area. Monthly workplace visibility tour by middle and senior managers in their work area.	% Scheduled inspections complete by name and work area/dept, including contractors % Actions arising complete by name and work area/dept % Visibility/inspection tours complete
Employees and contractors working safely	Behaviour based observations	% Employees working safely % Personal Protection Equipment - procedural compliance
Incident reporting and implementation remedial measures	Timeliness of reporting Incident investigation Log of corrective actions Effectiveness	% Incidents reported within 24 hours % Near miss incidents % Incident investigation complete on time % Corrective actions implemented
Safe and competent employees and contractors	Performance and training needs assessment Training records	% Performance assessments complete % Scheduled training complete
Improve safety awareness	Toolbox talks on targeted topics monthly by all supervisors	% Toolbox talks complete by Dept. % Employees attending % Actions arising complete % Safety representatives trained
Improve safety culture	Annual safety climate survey	Overall findings on safety culture based on key lag and lead indicators

Table 2: Safety Outcomes Monitoring Using Leading (PPM) Indicators

The competency-based model is also consistent with the objectives set out by IAEA both in the 2001 Safety Guide, [9] where the concept of competence enters the title of the work, and in the Safety Report **Training in Radiation Protection and the Safe Use of Radiation Sources**. [10] The outcome of adopting such an approach as advocated in this paper is a skills matrix as shown in Table 3. This table uses both a NORM industry, phosphates, and medicine as worked examples to demonstrate how broadly generic building an RP safety culture can be.

2.8. The competency-based approach

Adopting a competency-based approach has the operational advantage of allowing on demand delivery of training and professional development. It is also fully consistent with a "train-the-trainer" methodology by which one or more individuals in each RP organisation are assigned responsibility for training within that organisation, having first been trained into this task with the assistance of the RP profession's leadership and other bodies and stakeholders such as national governments, IRPA and the IAEA itself.

3. Systemic Training and Capacity-building – Building from Within the RP Profession

If one of the keys to creating sustainable RP culture in the African region is systemic capacity building, there needs to be a system developed and put in place to achieve this. One of the constraints of such a process, which has not yet been fully addressed is the fact that for many trainees the training itself is de-contextualised, abstract, divorced from the work place. This is unsurprising in that, as for example in nuclear power, building and operating a power plant in which RP personnel can operate in a real, live environment is a generational effort in and of itself. So part of the process of working systemically involves looking across the spectrum of activities involving RP and seeing where opportunities exist for cross-over training. An excellent example of this was the use in South Africa of a very broad base of RP professionals for operating security devices during the Football World Cup, 2010. Such events are however, extremely rare and very localised. So it is probably in the field of medicine where the most immediate opportunity lies for such cross-sectoral training.

3.1. Case Study: Medicine

The explosion of diagnostic and therapeutic uses of radiation in medicine in general and oncology in particular is nowhere more evident than in Africa, especially in the fast-growing "lion" economies [11] where average per head GDP is actually running some 50% higher than in the much better known "BRICS". The impact of this boom can be felt across a wide range of medical departments, such as Radiotherapy, Nuclear Medicine, Radiology, Cath labs, Dentistry, Urology, Cardiology, Pediatrics, and even Ophthalmology, with non-ionizing radiation using different types of laser. Of course, such a boom is not just confined to Africa. Against the background of an unequivocal commitment to the safe use of radiation in medicine, the default position must be to recognise, and hence mitigate or wholly prevent, the potential risk to both patient and staff that may stem from inappropriate or careless use of radiation. The operational causes of such risks may include poor, insufficient or inappropriate training, weak or absent ethical standards, and missing or inadequate operational policies and procedures. The causes can also lie in poor management, as for example, in inadequate or failed communications between top management and technical radiation staff. This may lead to underestimating the risks inherent in unsafe use of radiation, and breaches of compliance in respect of failing to follow strict regulations and good practices designed to prevent radiation risks. Such issues at the hospital or clinic level in turn may be caused, or aggravated by missing or inadequate laws, regulations or standards on the part of government in respect of safe uses of ionizing and non-ionizing radiation, or a failure to enforce such measures, including sanctioning and punishing those who breach them, with or without institutional tolerance or even encouragement.

Another potential cause of operational shortcomings may be uncertainty between different professional groups as to precise roles and responsibilities. This may open up unacceptable gaps in the chain of custody, prevent seamless patient care or even cause harm from radiation accidents or damage to equipment. These behaviours may even manifest themselves in territorial or boundary disputes between such groups, leading to abrogations of professional standards of conduct, either between professionals themselves or towards the patient. A good way to counter this risk is to insist

on teamwork grounded in multidisciplinary practice, where the team has joint and several responsibility for safe, beneficial service delivery to the patient. Based on such potential causes of unsafe behaviours, the ideal measures for developing and sustaining systemic capability in the safe use of radiation in medicine, organisation-wide, (the safety culture) are:

- continuous training and professional development for all levels of staff working in or managing radiation facilities, focused on a culture of safety
- the enactment and enforcement of appropriate laws and regulations the creation of professional bodies and associations to which staff can belong, each with its own codes of conduct, models of competency and disciplinary procedures, aligned to particular levels of professional responsibilities and/or duties
- the establishment of an independent quality assurance department or unit with responsibility for determining, monitoring and enforcing policies and procedures for safe radiation use
- the use of both internal and external auditing techniques to monitor, analyse and enhance work flow and operational procedures, and to build systemic capability through the exchange of experience, the digestion of lessons learned, and targeted intervention as needed. A particular requirement is to detect and treat any likelihood of the occurrence systematic mistakes or behaviours that may lead to radiation risk or accidents or harm any of the patients or the working staff. The use of positive performance measures is indicated.

3.2. Case Study: NORM Industries

The IAEA is publishing a series of Safety Reports on NORM Industries. Although traditionally considered separate industries, the lines between them have blurred. The phosphate fertilizer industry periodically co-extracted uranium for the nuclear fuel cycle in the past and may do so again in the near future. In the interests of environmental stewardship and economics, comprehensive extraction of all useful materials from ore, regardless of the primary commodity, has gained global traction. As such, the phosphate industry is now considering extraction of uranium and rare earth oxides in addition to the primary phosphate product. However, commodity prices and margins are still expected to drive extraction initiatives. In addition, rare earth mines that were closed due to poor market conditions are opening again and may find that comprehensive extraction, where practical, could soften the impact of a single fluctuating commodity market. New extraction technologies and co-located facilities may lead to new challenges and training requirements for radiation protection. RP training requirements will largely overlap for many industries, with significant departures along lines of specialization. Consider a comparison between NORM industries in general and medicine.

Radiation safety is not only an important issue for medical staff, but also for impacted members of the public. Radiation doses to patients have abruptly increased over the past two decades with increased availability and use of advanced equipment and procedures for diagnostic and interventional medicine. Competency-based training can play a vital role in the reduction of unnecessary excess patient dose, while delivering improved outcomes. The ICRP states that "many of the millions of medical personnel using radiation-producing equipment or those ordering procedures involving ionising radiation have little knowledge or appreciation of potential radiation effects or optimisation methodology. [12] With the rapid expansion of medical procedures, education and training in this area have become urgent priorities." For some medical professionals "there has been a considerable lack of education and training in a large part of the world, and this needs to be corrected." [12] Some professional categories "shall have formal education in RP and a formal examination system to test competency before the person is awarded a degree. Formal training in RP with proven professional competency through professional certification is needed *in addition to* (emphasis added) education before he/she is qualified and entitled to practice the profession and teach others to practice."

According to the Commission "Training in RP given to interventional cardiologists and other medical doctors conducting interventional fluoroscopy-guided procedures (e.g. vascular surgeons) in most countries is limited" and "provision of more RP training for these groups should be a priority." This training will decrease collective dose and risk to patients and staff alike. [13]

Level	Generic	NORM / *Medical* Operational	Safety Hurdle + *Medical*	Management
1. Novice	• Works to taught rules or plans • Little situational discrimination (e.g. between safe/ unsafe behaviours) • No comparative judgment	• Works directly with NORM-bearing or contaminated objects • *Students undergoing supervised training in a clinical setting*	• Must be taught basic radiation safety principles, e.g. justification, optimisation, dose limitation; ALARA • Must be taught to use PPE • *Must be taught basics of dose limitation to patient doses and workers*	**Requires constant supervision** • Task-specific
2. Advanced Beginner	• Follows guidelines for work aligned to key task attributes or aspects • Some situational discrimination (e.g. safe/ unsafe) • All attributes and aspects are treated separately and given equal importance	• May perform routine radiation surveys or sampling, unsupervised • May be specifically assigned to work in higher NORM exposure situations • *May provide care of nuclear medicine patients* • *Advanced student/intern* • *Medical referrers (including some medical students)* • *Referring chiropractors* • *Regulators*	• Must be taught radiation safety principles in more detail, e.g. radioactivity and radiation, biological effects, dose and risk, limits, use of survey equipment and personal dosimeters *(for those in exposure situations)* • *Must follow established SOPs specific for equipment to minimise patient and worker doses* • *Must know typical doses of prescribed procedures* • *Must understand the application of risk in the justification process* • *Must understand the importance of the optimisation principle and the use of diagnostic reference levels in managing the exposure of patients* • *Must understand risks to pregnant women (staff and patients) and foetuses*	**Works largely unsupervised** • Task-specific • Procedural –tasks are concatenated into a coherent process or flow sheet
3. Competent	• Multi-tasking – can also prioritise • Contextualises routine actions in terms of longer-term goals • Methodical planning with limited adaptability • Differentiates standardised and routine procedures from exceptions • Can diagnose and remedy routine faults • Follows all safety procedures; anticipates and prevents risks	• May supervise teams working in NORM exposure situations • May participate in drafting Radiation Work Permits • May participate in planning for decontamination, decommissioning, or waste disposal activities, including QA/QC • *May supervise teams working in diagnostic and interventional radiology departments* • *May operate, maintain or test x-ray equipment* • *May use pharmaceuticals in nuclear medicine including PET or PET/CT* • *May use radionuclides for diagnostic purposes such as radioimmunoassay* • *Radiographers, nuclear medicine technologists, x-ray technologists, maintenance engineers and clinical applications specialists, podiatrists, physiotherapists, speech therapists, nurses, dental care professionals, radio-pharmacists and radionuclide laboratory staff*	• Must be taught to supervise a team working in a radiation environment • Must be taught to recognize and characterize an exposure situation • Must be taught how to assess dose and manage time, distance and shielding to keep doses ALARA • Must be taught radiological waste management	**Supervises, within defined framework** • Interpersonal – such as communications (oral and written) and teamwork • Contextual –demonstrates capacity to work within the wider operating or process environment • Reporting - outputs
4. Proficient	• Understands situations holistically • Knows quickly what is most important in a situation; reacts instinctively safely • Perceives deviations from the normal pattern and is adaptive • Practised at decision-making • Uses maxims for guidance, whose meaning varies according to situational need, and can direct others	• Will be placed in charge of health physics duties for a site or company to include: o site characterization and monitoring, o personnel monitoring, o shipping, o reporting o regulatory compliance • May construct and direct corporate initiatives May author corporate policies, procedures and best practices • *Radiation safety officer, radiologists, nuclear medicine specialists, cardiologists and interventionalists from other specialties (vascular surgeons, neurosurgeons), other specialists using x rays (urologists, gastroenterologists, orthopaedic surgeons), other specialists using nuclear medicine, assisting physicians (anaesthetists, occupational health physicians who review records of radiation workers), dentists, medical physicists*	• Must acquire skills to function as site or corporate Radiation Safety Officer • Must be able to design radiation safety and environmental monitoring programmes • Must be able to analyze dosimetry and environmental data • Must be able to report analysis results to corporate officers and regulatory agencies	**Manages/ Decides** • Performance – optimisation • Contingent – such as dealing successfully with the unexpected or unforeseen • Accountability – legally liable for radiation protection decisions made on behalf of the company
5. Expert	• No longer relies on rules, guidelines or maxims • Intuitive grasp of situations based on deep tacit understanding • Defines performance and safety outcome measures; can spot emerging trends • Analytic approaches used only in novel situations or when problems occur • Vision of what is possible	• Is capable of adapting existing or developing new policies and procedures for contingent or unforeseen events • Is capable of strategic planning and foresight including what-if modelling and scenario development • Is capable of developing innovative strategies for radiation protection • Will participate in technical dialogue with standard-setting or regulatory agencies • Will develop the corporate *(or hospital)* vision on how NORM is used, avoided, or otherwise managed/ *how radioactive materials or radiation-generating equipment are* used, avoided, or otherwise managed	• Must have access to information in order to evaluate NORM impacts for a company or entire industry • Must have expert knowledge of radiation principles and NORM to author policies, procedures and best practices • Must have access to information in order to contribute to organizations that set standards or draft regulations	**Leads** • Defines, evaluates, redefines processes and competencies • Influences scientific debate and regulatory policy • Influences or establishes corporate vision and mission statement

Table 3: Towards a Generic Competency Model for RP – Example, NORM and Medical Applications Compared

Conclusion: Systemic Capability Starts from Home Base

The challenge of creating systemic, sustainable capability in the African region, and perhaps beyond, begins at the door of the IRPA community itself. The RP profession is, or perhaps has become, very tribal, even elitist, based on and strongly aligned to industry / activity allegiances, such as nuclear power and medicine, which by sheer presence risk overpowering lower profile activities, such as NORM industries. Can IRPA itself as a body find a way to see beyond this tribalism, crucially by building an entry level training culture that is generic and transferable? In meeting this challenge we have as a working team put ourselves to such a test and assembled a provisional version of a competency model, and a derived curriculum and training methodology that offers such a solution. Just how generic an outcome this can yield is shown in Table 3 above. It is we believe, possible to create a single framework within which RP as a single professional community can operate, allowing for each of the different sectors to develop specialist competencies, but from a common base of both knowledge and practice. For Africa at least, our case is that in the absence of such an approach no sustainable systemic progress will be made, however much individual training courses and interventions succeed.

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