BACK TO THE FUTURE
Biennial Symposium: 10 – 11 October 2012

Engineering Capacity
The Human Capital Challenge

11 October 2012

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saice

RAILWAY & HARBOUR DIVISION

CONTINUING EDUCATION
UNIVERSITY OF PRETORIA

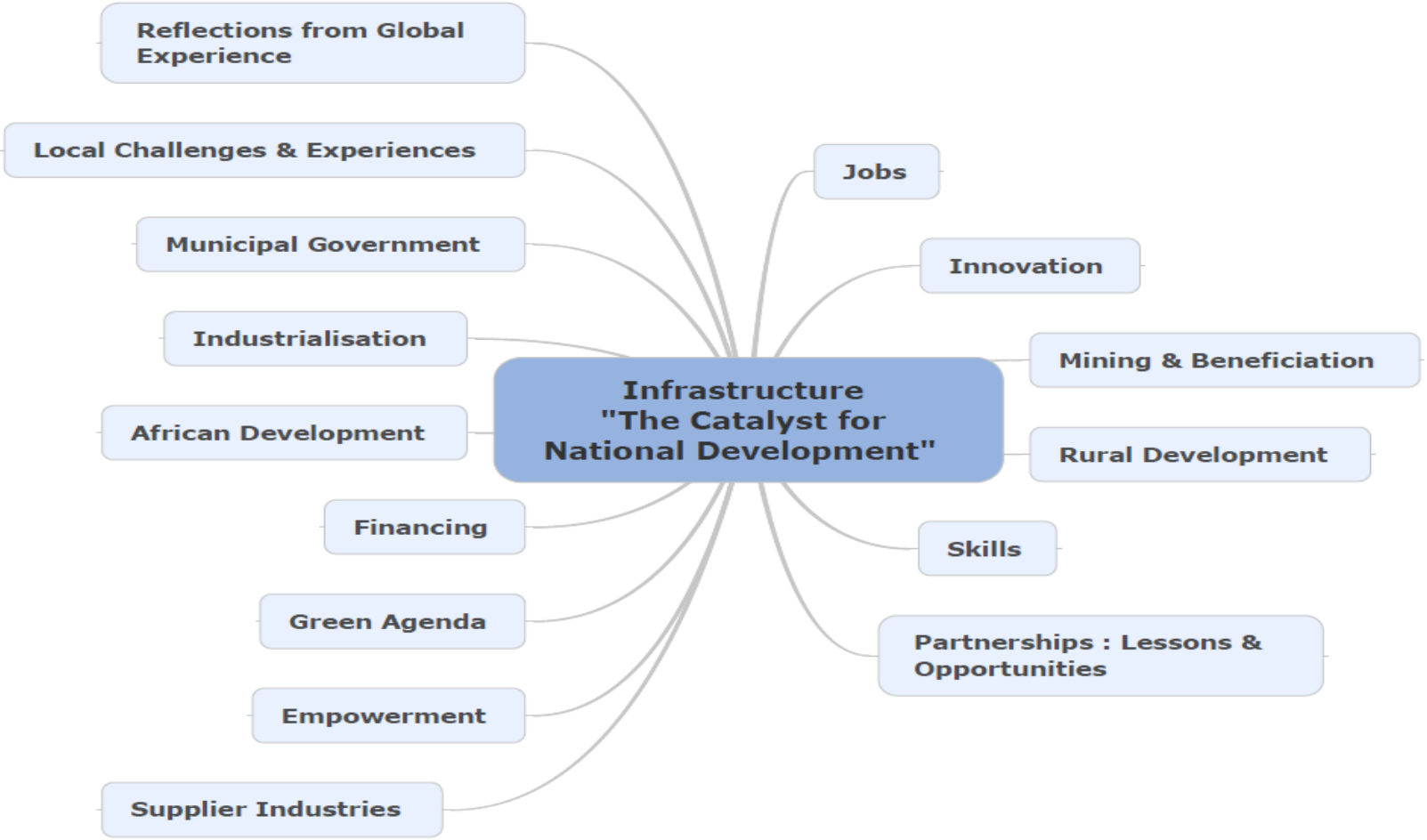
“IT IS NOT OUR WEALTH THAT CREATED OUR INFRASTRUCTURE, IT IS OUR INFRASTRUCTURE THAT CREATED OUR WEALTH”

John F Kennedy

Setting the Scene

- **Post 2010 decline in infrastructure investment;**
- **Planned Infrastructure Roll Out by Govt. – State of the Nation 2012;**
- **Underspent in 2010/2011 budget;**
- **Industry decline in business levels with limited business from public sector;**
- **Less than 400 000 jobs created in 2011;**
- **Shrinkage in employment of engineering practitioners and limited opportunities for mentorship;**
- **Required Economic Growth – 6%, Actual YTD 3.4%, predicted 4.4% to 2013;**

Infrastructure Development – Catalyst for National Development



Engineering Capacity

- **Is Engineering Skills Shortage, Myth or Fact ?**
- **Studies in 2005 and 2007 (Allyson Lawless) reflect that South Africa has significantly higher citizens per engineer ratio than its BRICS counterparts;**

The following anecdotal evidence points to a conclusion that there is no overall shortage of engineering resources in South Africa:

- **The consulting engineering sector has resorted to cost-competition strategies as a survival strategy to retain capacity in an extremely volatile work flow situation;**
- **Companies in both the consulting and contracting sectors are actively developing market share in markets abroad using South African engineering capacity;**
- **Retrenchments of engineering professionals as a consequence of lack of work load in consulting and contracting companies occur periodically;**
- **Engineering professionals migrate to other economic sectors where their skills are required and valued;**

Engineering Capacity (cont.)

- **Many Municipalities, Provincial Government Departments and SOE's however, do not have sufficient engineering capacity due to a mixture of attraction issues, hygiene issues and retention issues;**

- **Furthermore, the need for Engineering Capacity should however not be viewed in the narrow context of infrastructure development only, we need to view it in the broader context of skills required for industrial development, growing the beneficiation and manufacturing sector and the R & D capability to increase our global competitiveness;**

Defining the Shortage

- **Limitations exist in the ability to accurately quantify the number of Engineers, Technologists & Technicians we should have for following reasons :**

  - Registration with ECSA is not mandatory, due to deficiency in Engineering Professions Act, hence it captures number of registered persons only;

  - Graduation numbers available from various sources available from 1918 to 2010, however, not all graduates go into engineering, many pursue alternate careers in financial sector for example;

  - **Best attempt made at quantification using two approaches :**

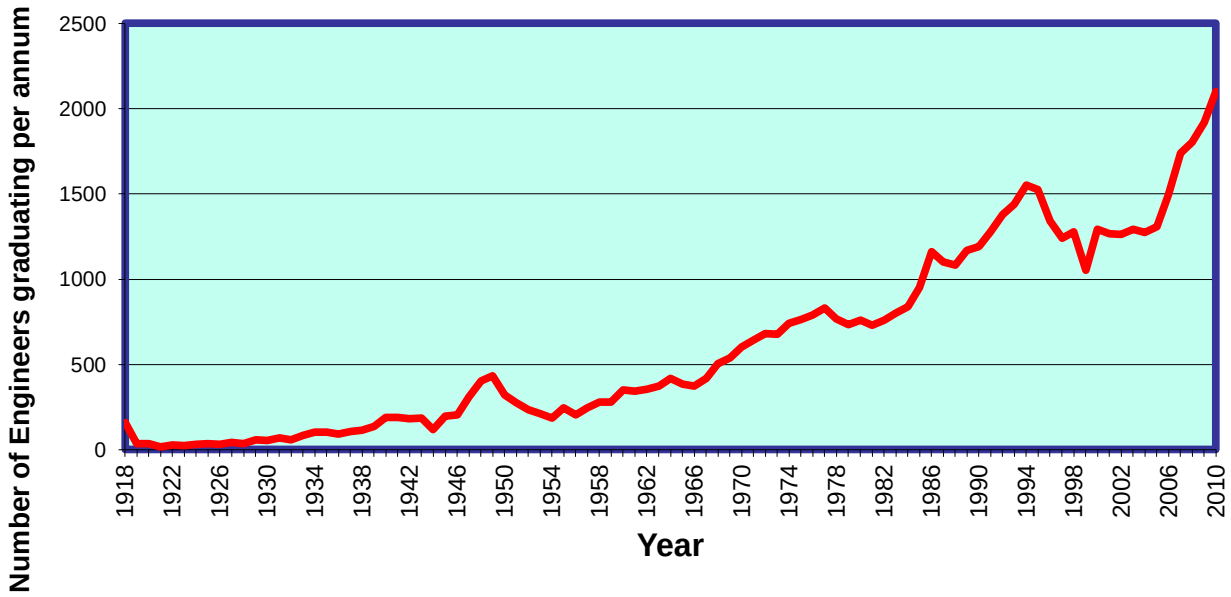
    - Determining graduation figures and estimating attrition rates over the years;

    - **Using current registration figures and indicative ratios of registered to non-registered persons per discipline to determine number in industry;**

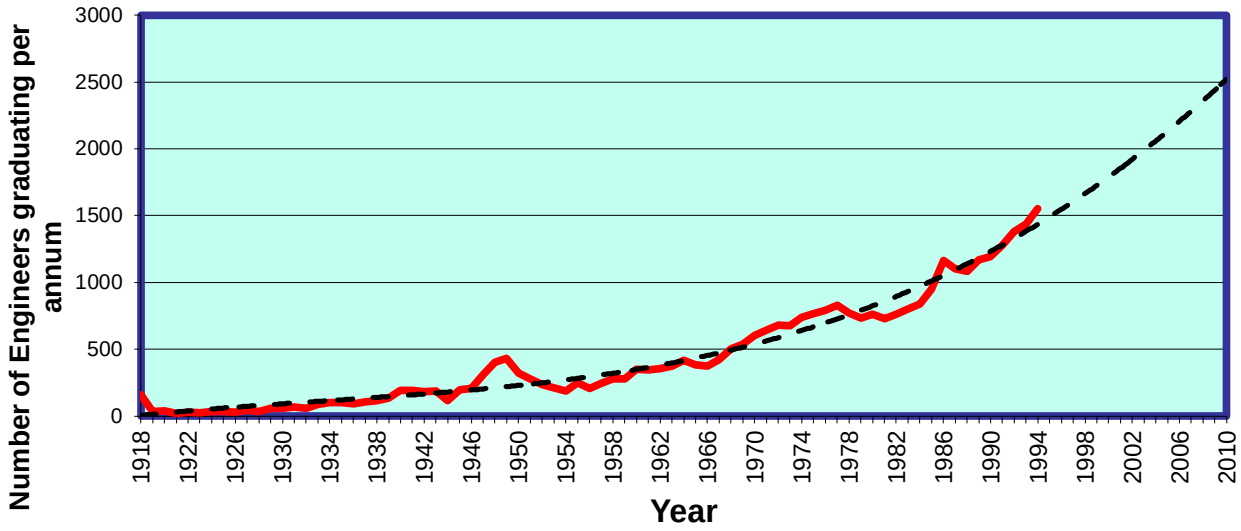
The graphs that follow provide an understanding of how we have been able to derive the best estimate of the current numbers of Engineers, Technicians and Technologists in the country.

Category/age	<25	25-34	35-49	50+
Engineer	2%	28%	71%	86%
Technologist	7%	33%	60%	70%
Technician	1%	5%	13%	11%

Ratio of registered to total numbers of engineers, technologists and technicians (Lawless, 2005)



Graduation of engineers from South African Universities since 1918



Possible graduation projections for engineers post 1994

The graph above shows the possible trend line had graduations continued at the pace shown prior to 1994. Extrapolating the data suggests that at least another 400 engineers a year should have been graduating, which today would equate to an additional 7200 graduate engineers**.**

In carrying out the analysis of current numbers still active, it is assumed that few engineers over the age of 75 are active. Assuming a graduation age of 22 years old, graduations from 1959 onwards will be considered. The Table below offers an estimate of the attrition percentage per decade since graduation and suggests that the total number of engineers currently in the system is of the order of 32 800.

Years	Total Graduations	% Attrition	Rationale	Plus Immigration	Rationale	Nett
1959-1968	3808	80%	Past retirement age	76		838
1969-1978	7036	60%	Reaching retirement age and early retirements	563	Moss Gas, Power Station projects, Mining boom etc	3377
1979-1988	8919	50%	Large numbers of emigrations	892		5351
1989-1998	13393	50%	Large numbers of emigrations	670		7366
1999-2008	13796	25%	Research carried out in 2004 and 2005	1552	SWC, other major projects, plus brain gain from Africa	11899
2009-2010	4018	10%	Input from tertiary institutions	362		3978
TOTAL	50970			4114		32809

Total number of engineers in South Africa in 2011, based on the attrition of graduate numbers plus effect of immigration

The current registration statistics are shown in the Table below. The total number of engineers under 75 who are still registered with ECSA is 12820. Research has shown that on the whole older engineers registered with the then South African Council for Professional Engineers. In the past 20 years, there has not been pressure on engineers to be registered and it has been found that in the past 10 years, low numbers of engineers have registered in relation to the number who have graduated as shown in row 4 of the Table below. Using the ratios shown for each age group, the total number of engineers in South Africa is estimated at 32300. This compares well with the model determined using graduation figures, and immigration and attrition estimates.

Estimated numbers to age 75	TOTAL	Aeronautical	Agriculture	Chemical	Civil	Electrical	Industrial	Mechanical	Metallurgy	Mining
Registered Professional Engineers	12820	48	170	732	5400	3163	164	2465	282	398
Engineers - older group - generally 2/3rds registered		66%	66%	66%	66%	66%	66%	66%	66%	66%
Younger Engineers registered in past 10 years, determined by recent research		10%	24%	11%	33%	13%	4%	16%	19%	28%
Total engineers in industry	32300	175	369	2494	10227	9677	1208	6653	690	808

It can therefore be assumed that the total number of engineers is of the order of 32000 to 35000. More time is required to carry out more detailed research if a more accurate figure is required.

Estimate of the total number of technicians in South Africa based on registration statistics

Registered	TOTAL	Aeronautical	Agriculture	Chemical	Civil	Electrical	Industrial	Mechanical	Metallurgy	Mining
26-30 years	311	0	0	4	54	225	1	25	1	1
31-35 years	668	0	0	7	138	458	2	57	1	5
36-50 years	1761	0	5	5	301	1081	6	262	12	89
51-65 years	1494	0	6	2	284	727	10	370	7	88
> 65 years	703	1	0	0	117	276	13	279	0	17
Total registered	4937	1	11	18	894	2767	32	993	21	200
Total in industry from 1986-2010, assuming 10% registered	27400	0	50	160	4930	17640	90	3440	140	950
Total in industry from 1959-1985, assuming 11% registered	16777	5	55	18	3114	7864	150	4632	64	877
Estimate of total technicians in industry	44177	5	105	178	8044	25504	240	8072	204	1827

Estimate of the total number of technologists in South Africa based on registration statistics

Registered	TOTAL	Aeronautical	Agriculture	Chemical	Civil	Electrical	Industrial	Mechanical	Metallurgy	Mining
26-30 years	86	0	0	7	28	34	1	10	3	3
31-35 years	461	0	0	25	204	142	0	79	8	3
36-50 years	1656	0	7	27	787	506	13	274	29	13
51-65 years	1292	0	4	4	596	457	5	208	11	7
> 65 years	496	0	0	0	185	168	4	136	0	3
Total registered	3991	0	11	63	1800	1307	23	707	51	29
Total in industry from 1986-2010, assuming 33% registered	6676	0	21	179	3088	2067	42	1100	121	58
Total in industry from 1959-1985, assuming 66% registered	2333	0	6	6	1043	820	11	418	17	13
Total technologists	9009	0	27	185	4131	2886	53	1518	138	70

Combining the total number of technicians and technologists gives a total of 46 800. This is 12% higher than the estimate calculated from graduations, but suggests that ball park figures for the number of engineering technicians and technologists in South Africa ranges between 40 000 and 55 000.

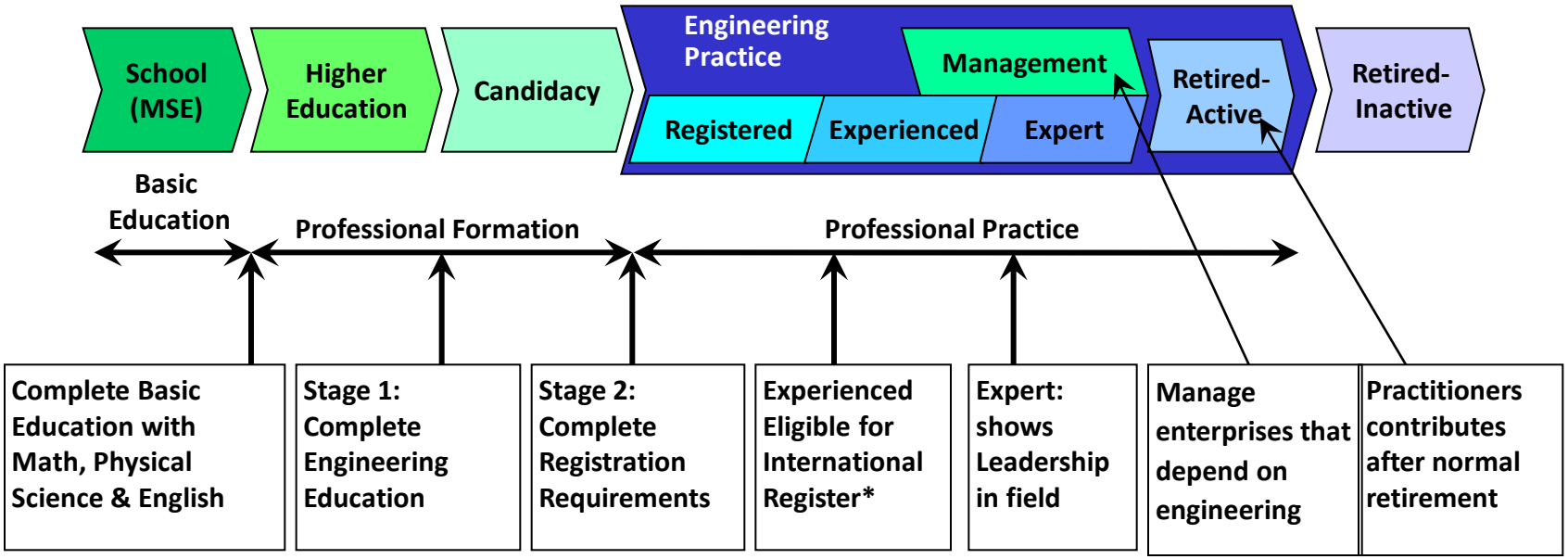
- **The loss of skills and competence by the Engineering Profession has possible serious implications for the appropriateness and long term viability of projects implemented in the National Infrastructure Development Plan, particularly in relation to project sustainability and public health and safety.**

- **This knock-on effect cannot be countered by simply producing more engineering resources by increasing the graduation rate at Universities. The lead time to educate and train a competent engineer to a professional level can be up to ten years if one factors in the fact that most graduations take place after five years and that it takes a minimum of three years through a well-structured mentorship programme " with a willing giver and willing receiver" to render the individual eligible for professional registration.**

- **This process is evidently inadequate to meet the time constraints for the for the start of implementation of the important National Infrastructure Development Plan, however it must be reiterated that acceleration of this process will serve only to provide insufficiently competent persons and that further development will be required to ensure that a sustainable cadre of confidently competent professionals are developed to mentor and develop future generations of professionals.**

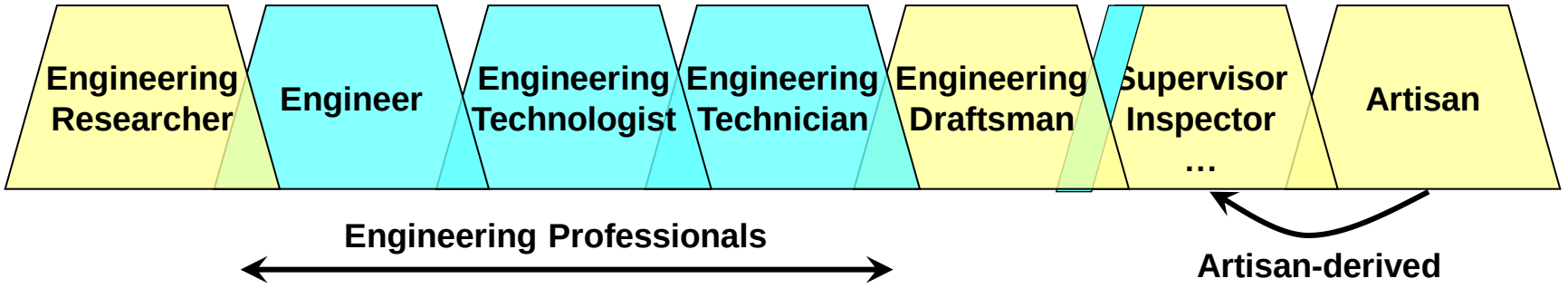
- **Unfortunately, the applied science nature of this profession, based on practice and not only qualification, not too unlike the medical profession with similar inherent risks to public health and safety, though in much larger scales (e.g. bridge collapses pose fatality risk to large numbers of people), makes it impossible to short circuit the process required for professional competence.**

Engineering Practitioner Lifecycle



ECSA Register of Engineering Professional: ~ 35 000

The Extended Engineering Family



- Various Engineering activities require above role players in different measures;
- Need to balance capacity along the entire value chain;

Typical Rail Project (1km)

PROJECT DEVELOPMENT PHASE			
Major Function	Occupation title	Number requiring more than 15 years experience	Number requiring between 5 and 15 years experience
1. Environmental scoping	Environmental Protection	1	1
	Environmental Engineers	1	
2. Site investigations	Civil Engineers	1	
	Land surveyors	1	1
3. Route Planning	Civil Engineers	1	
	Draughtspersons	1	1

ENGINEERING PHASE

Major Function	Occupation title	Number requiring more than 15 years experience	Number requiring between 5 and 15 years experience	Number requiring between 0 and 5 years experience
1. Civil Design				
Earthworks	Civil Engineers	1	1	1
Drainage	Civil Engineers		1	1
Bridges and Structures	Civil Engineers	1	1	
2. Track Design				
	Civil Engineers		1	1
	Civil Engineering Technicians		1	1
3. Electrification				
Substations	Electrical Engineers		1	1
	Electrical Engineerng Technicians		1	1
Traction	Electrical Engineers	1	1	
	Electrical Engineering Technicians	1	1	1
4. Signalling				
	Signalling Engineer	1	1	1
	Electronics Engineering Technician	1	1	1

CONSTRUCTION PHASE			
Occupation title	Number requiring more than 15 years experience	Number requiring between 5 and 15 years experience	Number requiring between 0 and 5 years experience
Civil Engineers	1	2	4
Civil Engineering Technicians	1	2	4
Environmental Egineers	1	2	2
Electrical Engineers	1	2	4
Electrical Engineering Technicians	1	2	4
Electronics Engineers	1	2	4
Electronics Engineering Technicians	1	2	3
Telecommunications Engineer	1	2	3
Draughtspersons	1	2	4
Construction Managers	1	1	
Construction Supervisors	2	4	

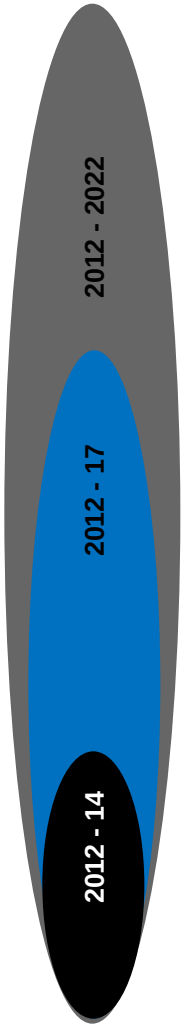
OPERATIONS AND MAINTENANCE PHASE

Major Function	Occupation title	Number requiring more than 15 years experience	Number requiring between 5 and 15 years experience	Number requiring between 0 and 5 years experience
1. Signalling: Testing & Commissioning	Electronics Engineers	1	1	1
	Electronics Engineering Technicians	1	1	1
2. Electrical Installations	Electrical Engineers	1	1	2
	Electrical Engineering Technicians	1	1	2
3. Civil Engineering	Civil Engineers	1	1	2
	Civil Engineering Technicians	1	1	3

• It should be noted that the loss of technical capacity in government organisations, at professional and at artisan levels, brings with it an inability to create, operate and maintain economic infrastructure. Rail and Ports are no exception. This results in the organization being exposed to unacceptably high risks. Such risks include not only the consequences of failure in Project Governance referred to above but also exposure to the liability for the consequences of inadequate duty of care being given to infrastructure, equipment and facilities;

•Whilst addressing skills shortages in the private sector may be addressed by augmenting these with expatriates and spare capacity from other countries as this is normally the process adopted for large scale capital works, re-capacitating the public sector at the various levels remains an imperative with its own challenges;

Short, Medium & Long Term Action Plan



Long term : 2012 -2022

Start training towards fully populating the structures designed in the medium-term. This will require the issuing of bursaries and major training programmes in all public sectors structures, workplace training, mentoring and coaching etc. Consider career paths, succession planning etc. Also consider other members of the engineering team such as artisans, operators, semi-skilled etc. and other professions such as planners, surveyors, building inspectors, laboratory technicians, property valuers, development economists etc.

Medium term : 2012 -2017

Re-develop the technical structures and systems required in public sector organisations and start populating them with available skills. This will include planning and design departments, project management units, teams responsible for infrastructure asset management, operations, maintenance, compliance and enforcement, and train existing in-house mostly junior technical staff to perform all these functions

Short term : 2012 -2014

Harness the private sector, retired engineers, overseas capacity etc. as we did in the case of the 2010 Soccer World Cup to get the major projects off the ground, and set measurable and auditable training conditions to all projects to ensure current graduates adequately trained

Closing Remarks

- Action be taken in the Short Term to create professional engineering capacity in public sector organizations that are responsible for implementing components of the National Infrastructure Development Plan. Various options are suggested for the Short Term initiative;

- Focused plans be implemented to ensure stability in the Engineering components of public sector organisations in the Medium Term;

- For the Long Term the public sector should be professionalised with competent and responsible persons in every post where this is called for. It is envisaged that the State becomes the employer of preference among engineering professionals, leading to a capable State being rebuilt , as expected by the National Planning Commission, whether it is in Municipal, Provincial or National Government or any of our SOE's such as Transnet, Eskom, Telkom or Denel;

INDEED, WE HAVE TO GO BACK (TO THE PAST SOMEWHAT), IF WE ARE TO REALISE THE FUTURE !!!!!

Thank You !!!!!