# ‘Make sure you pour the concrete and get something on the ground’

## — and other critical success factors in high-tech infrastructure projects

ROB ADAM is a distinguished theoretical nuclear physicist. He is also a veteran of the liberation struggle, who spent 10 year in prison for ANC activities. After 1994, he became a leading civil servant and manager of key developmental and scientific projects. He is now the managing director of the South African Radio Astronomy Observatory, which includes the African Square Kilometre Array (SKA) radio-telescope. Professor ALAN HIRSCH, also a long-term senior civil servant, is the founding director of the Nelson Mandela School of Public Governance based at the University of Cape Town.[1]

*The authors are in conversation about an article by Adam, published in Social Dynamics (Adam, 2020), on the critical success factors needed in high-technology infrastructure projects. This exchange took the form of a webinar for the masters students of the School of Public Governance.*

The conversation has been edited for length and clarity.

**Alan Hirsch: I think one of the things that made you successful as a senior government official was the way that you managed communication. Effective communication with key political stakeholders starts with cabinet. But beyond cabinet, effective communication with other key stakeholders is vital: the science community, the academic community, the research councils, the private sector and other government departments. What is your advice on this?**

Rob Adam: You have to try that much harder. Science and technology in South Africa is a Cinderella portfolio which is not seen as the bread and butter of government. South Korea has a deputy prime minister responsible for science and technology with a remit over several portfolios. They are special in that sense. They’ve used science and technology to build their country. Usually the key departments are commerce/trade and industry, defence, foreign affairs, home affairs. Science is seen as a ‘nice to have’ which may be amalgamated with trade and industry or education or whatever.

During those early years, when we were building a new country, ministers would come to me and the senior officials saying, ‘why are you bothering with research and other stuff that’s in the future? For [more than] four decades we’ve been thinking about the future. Now we are in it, you want money for something else, in another future. The money should go to building roads and schools and sanitation, so leave that stuff.’

My challenge was to counteract that. You want science to penetrate people’s lives and do helpful and useful things for them. But what knocks people’s socks off are the SKAs and the big projects like that. It takes their breath away and makes them proud to be South African.

Over the past 15 years or so we’ve created a community, which now makes us the strongest BRICS country in terms

of science impact in astronomy. We are better than China and Russia and India and Brazil.

**AH: Why did you choose to review the success and failure of three big science projects [the Pebble Bed Modular Reactor, the Radioisotopes Reactor Conversion Project and the Square Kilometre Array radio-telescope]. What interested you about them?**

RA: It was because I was intimately involved in all three of them. It wasn't an academic view from outside. It was an insider's view and I was trying to think back on my experiences and insights into what went right and what went wrong in these three projects.

I was the principal civil servant who pushed my peers to persuade ministers for cabinet to agree that we should bid for the SKA. I then took a detour into the nuclear industry and the private sector and I've now come back essentially to implement the project that I started with at a policy level.

The SKA is a radio-telescope consisting of an array of huge antennae-like TV dishes, each 15 metres across, that can be steered in any direction to collect and amplify faint signals from stars, galaxies and clouds in distant space. A huge amount of electronic data is collected and analysed by scientists in South Africa and all over the world.[2]

The Pebble Bed Modular Reactor (PMBR) never got built, although more than R10bn was invested in it by South Africa's taxpayers. A PMBR is a type of small nuclear reactor for generating heat and electricity. It is 'modular', meaning that you can use one or more units, flexibly, depending on your power needs. Our PBMR was designed to provide safe, carbon-free power – and to use South Africa's beneficiated natural resources, such as uranium. It would provide electricity for rural areas that had no coal deposits or water resources for power generation. The technology had been developed in Germany, up to the prototype stage, when Eskom bought the intellectual property rights to it. Eskom intended to sell these 'next generation' power units all over Africa, to modernize development – *Editor.*

With the PBMR, the Pebble Bed Modular Reactor, I had been kind of on the edges of it for some time but eventually ended up on the Board. At first there was a great deal of naivety, where Eskom said all it really wanted was for government to give permission for the project to go ahead, because Eskom could fund it. It was really just a regulatory issue for them.

[On the Radioisotopes Reactor Conversion Project (RCP)] we know apartheid South Africa had a nuclear weapons capability. In fact, it made seven nuclear devices in the 1980s. Before the transition to democracy in 1994, then-president FW de Klerk admitted that South Africa did have nuclear weapons, but was going to decommission them.

Over decades the ANC had strongly opposed South Africa's weapons programme. Even though the ANC knew it was there, the South African government had denied it. Just before 1994 it was very difficult for the ANC to say, 'well, no, we don't want you to do this [decommissioning]'.

It's good to decommission weapons. Even though it was [decided under] De Klerk, the ANC acquiesced in this. But many on the rest of the African continent were saying, ' This is only happening because they know there is a black government coming to power soon.'

South Africa went ahead with the decommissioning, and the highly enriched uranium was given to the Atomic Energy Corporation as its custodian. At the decommissioning, weapons were dismantled and disarmed. The uranium was melted down and safely secured at [South Africa's main nuclear research centre] Pelindaba.

Once you've created that kind of capability – with all of the infrastructure, the nuclear hot cells, the knowledge, the ability to manipulate radioactive substances, unless you are just going to abandon it, you have to redirect it. Very creatively, the scientists at the Atomic Energy Corporation were able to develop their own process for making medical radioisotopes, for use in the diagnosis of cancer and other diseases and also for their treatment, using that very same weapons-grade uranium. It was a classic swords to ploughshares story.

Here was South Africa, the only country in history to have walked away from its nuclear weapons capability, now reinvesting the knowledge garnered during the development of that capability in something which could help humanity.

Of course there's another side to this. We were still sitting on a lot of weapons-grade uranium. After [the al-Qaeda terror attack on the US on 11 September 2001] the US went around the world, wanting to corral all of the weapons-grade uranium that it could and consign that to one of the five designated nuclear weapon states, namely the US, Russia, China, France or the UK.

This created a need for an industrial process which could do the same thing for radioisotopes that the high end, highly enriched uranium industrial process did. They sent this challenge around the world to different scientific bodies that were linked with the US Academy of Sciences. There were copious workshops and meetings, all paid for by the US Department of Energy.

I was then Chief Executive of NECSA, the Nuclear Energy Cooperation of South Africa, and I had to sign requests for staff to travel, almost on a monthly basis, to these meetings, which were hosted by the US Department of Energy. I said to the delegation, 'you're going to all these workshops and meetings, but can we actually do this thing that they are wanting to us to do?' They wanted us to convert our processes away from weapons-grade uranium to low-enriched uranium which is less than 20% enriched. They said 'yes, sir, we can. There are a few challenges to solve, but we can do it.' So I said 'Well stop going to the meetings. Let's do it. Let's be first.'

And that is what we did. We became the first country to have an industrial process for making medical radioisotopes using only low-enriched uranium. And we were then able to get the US Department of Energy to help us to get further into the American market. The Canadians had most of that at the time.

We as South Africa, under the auspices of our Department of Energy, were able to boast about this on an international stage. We had done what no one, no other country, had done.


**Dr Rob Adam speaks at the Zoom webinar.**

**You want science to penetrate people's lives and do helpful and useful things for them. But what knocks people's socks off are the SKAs and the big projects like that.**

**AH: The first lesson was 'get something done'. What went right, what went wrong?**

RA: For any of these long-term projects, usually the length of the project is longer than an election term of any government, or the tenure of a particular minister, who would be the champion of the project. So it's important that something actually happens so that your principal, the champion, is able to get the credit for something. They can go back to their cabinet colleagues and say, 'okay, the money that we all voted for this, this is what happened, this is where we are, this is what's going to happen next.' But if nothing happens, after a while they lose credibility.

This is also linked to prototyping. You start small. You do make mistakes. But at least you pour concrete. And while you're pouring concrete and running different experiments, while you are getting the smaller system — the prototype — to work, you learn a whole bunch of stuff.

With the pebble bed, their view was that their prototype was the one that had been in Germany that ran for 21 years [at Jülich Research Centre]. But the problem was that even though they had the prototype in Germany, it wasn't their prototype, it was the Germans'. And what they planned to build wasn't a larger version of the German prototype. It was different, and so a whole lot of other technology challenges emerged. And they kept changing the design. They never poured concrete.

They had all sorts of plans — and the design changed. Then the clients got cold feet because it was taking too long and it was getting expensive, and so they never poured concrete at all. As a result, I believe the political stratum developed a disbelief in the thing. There was really only one minister who's was pushing for it at that point[3] and when he resigned the project disappeared. What they got wrong was just to take too long to do something.

In the case of the reactor conversion project, there had been things happening on an ongoing basis. There were new radioisotopes developed. There was the old weapons-grade based process which was in a way the prototype for the low-enriched uranium process.

We first converted the reactor. Then we took the spent fuel, which originally came from the US, because the reactor was part of the Eisenhower Atoms for Peace Programme.[4] We were able to send that spent fuel back to Savannah River.[5] There was a lot going on, which could attract the approval of not just the South African government, but the International Atomic Energy Agency.

Similarly with the SKA — it has been minutely prototyped at different stages, with each stage being something that there could be a launch of. We started off with one antenna, then seven, then 64 and so on. At each point, one could say, well, this is what has happened, this is what we've done, this is the science, this is what we can do with it. This is what we've learned. This is what we won't do this way, next time, because these particular components work, the way we thought they would.

**AH: The next point was, 'don't skimp on prototyping'.**

RA: You don't want to start the big part of your real project without prototyping because you can waste a lot of money if you get the final 'big design' wrong. If you don't test, if you don't prototype, you end up carrying the big mistakes forward into the actual project. Then you have to change the design as you go along. Instead of ironing out the problems with the prototype, you have to iron out the problems when building the real piece of infrastructure. When you change your design midstream that, of course (certainly with nuclear) involves regulators coming in. And they say, 'now we have to assess the whole safety case all over again'.

What happened with the Pebble Bed is that there were some challenges in the direct cycle process – where you had helium cooling the reactor and then helium driving the turbine blades directly – versus the indirect process – where the helium heats steam which drives the turbine. This was the old prototype process [used] in Germany, but they changed this completely in the pebble bed design. Challenges then emerged which were regarded as insurmountable within a reasonable period of time. Changing the design means going back to the nuclear regulator. That delays you. It feeds into never pouring concrete.

**AH: The next one you mentioned was 'have more than one strong champion'.**

RA: If you're working under the auspices of a particular minister, that minister is your principal. However, usually there are other portfolios involved in getting approvals that can also enjoy positive spin-off effects from projects.

For example, in the reactor conversion project, the Department of Energy was the protagonist, but [the ››

Department of] Foreign Affairs, now known as DIRCO, was a big beneficiary as well because of the International Atomic Energy Agency and the approval given to South Africa by that multilateral body. So there was very strong support from foreign affairs. Several different ministers would be involved in formal diplomatic processes, signing agreements, etc. There was a strong partnership between energy and foreign affairs, so that if the minister of energy was moved on, or resigned, you would have another minister who would have an intimate knowledge of the project and be able to support you.

Similarly, with the SKA. There were a number of ministers [that gave support], apart from the Minister of Science and Technology. Because of the other international players and the other countries involved, there was Foreign Affairs. Because of the huge bandwidth and data transport issues, there was the Minister of Communications. And then, of course, provincial and local government [gave their support]. Because of the huge extent of the telescope, part of it being in the Western Cape for the data processing and part in the Northern Cape, you had strong support from those provinces and their provincial governments as well. As a result, there was a robustness which carried the SKA through different administrations. There was no minister who came in who hadn't heard about it before. It wasn't seen as a narrow project for one department. There was a level of continuity which was made possible by the many champions across government that the project had.

In the case of pebble bed, it [had] really one champion and it was a very expensive project. And that particular minister would have to go to get money in competition with his cabinet colleagues. He would have to go to the head of state to overrule everybody and support the project. Of course, that made the project unpopular. It was seen to be sucking away too many resources. And so, when that minister resigned, everyone looked at one another and said, 'well, okay now what?'

The then Minister of Finance explained that his decision [to cut all funding for the project] had been based on [lack of] consensus. 'I could not see any consensus on this project, and so I withdrew the funding.' That project foundered on a number of challenges but this, I think, was the final *coup de grâce* for the project.

**AH: The next question involves 'understanding the market'. This was a particular issue for the pebble bed which depended on scale for its viability, and scale could only be achieved if they were clients outside of South Africa as well as in South Africa. In fact there were no committed clients and, as I recall, the potential clients backed off. As you said, no concrete was poured and there were more and more delays in the project. I think people were looking for validation of the project from the market which didn't seem to be there.**

RA: That's exactly right. It's like nuclear technology, the arms industry, where unless you buy your own product, nobody else does either. At one stage there was a strong Eskom buy-in. There was a letter of intent from Eskom to buy 24 PBMR units. That was later withdrawn and in the end replaced by an offer to buy whatever was constructed on Eskom's Koeberg site outside Cape Town for a nominal sum. Effectively there was no client and the fiscus, rather than the users of electricity, had to pay for the project.

Internationally as well, the main game in town was the big 'Generation III' nuclear reactors, rather than 'Generation IV', which is what pebble bed is. The big vendors like Westinghouse, Areva and Rosatom, the Russians, Koreans, Chinese, were much more concerned with marketing their own big Gen III plants than they were with Gen IV. Pebble bed was a technology a bit ahead of its time. At that stage there was a lot of enthusiasm in other countries because South Africa was taking the financial risk, but there wasn't really a market.

With the reactor conversion project, the main market was the big US radiopharmaceuticals market. [You had] to understand the drivers in that market in the context of 9/11 and understand that the US Department of Energy and the US National Nuclear Security Administration would keep partners in it. You had a kind of a three-cornered market where the Nuclear Security Agency and the US Department of Energy would give the nod, but then you also had to penetrate the actual commercial market as well. We got to understand that very well over the years through our relatively unsuccessful earlier attempts to penetrate [that market].

The Canadians were responsible for supporting the US market. We were lucky because at a particular point in time their reactor ran into significant problems (which were later fixed). We were able to take advantage of that window and get into the market. Once we brought the low-enriched uranium product onto the market, we were able to consolidate that position.

In terms of the SKA it's a different market. It's not a commercial market. The market is science and it's a question of understanding what the questions in physics and astronomy are and mapping those onto the capabilities of the instrument. It's always been very much a science-driven vision, even though obviously there's a lot of solid engineering underpinning it as well.

**AH: The next point you made was 'have the right culture'.**

RA: In any big, high-tech project you've got different strands. A lot of your engineers, in particular, tend to come from the defence industry because the defence industry by its nature is

high-tech as well – so you've got this strand with a military mindset. And those people are great on mission assurance. They will get the thing done, at all costs. The engineers, on the other hand, like to work to a specification. Otherwise, nothing gets built.

The third strand is the scientists, who get out of bed every day with a new idea, which they are hell bent on convincing the engineers to implement. So the engineers are then potentially persuaded to change the design.

As the leader of a high-tech project you have to balance all of those three strands quite carefully. If there's a big development in the science, you stand the risk of building the wrong thing. So you have to listen to the scientists to an extent. But if you listen to them too much, rather than to the engineers (which was the case with the pebble bed), you don't pour concrete.

So getting the culture right means finding the delicate balance between getting the job done at all costs (military), doing the job right (engineering), and doing the right job (science). You have to get those absolutely correct.

In the case of the PBMR they bit off more than they could chew. They kept not wanting to sign a shareholder agreement between themselves and Westinghouse and IDC and the other players. There was a sense that this was South African IP [intellectual property] and they didn't want to let go of it. But the problem is that once you take all the responsibility and all the kudos, you take all the risks as well. And when the pawpaw hits the fan, everyone stands back and watches, as opposed to rolling up their sleeves and helping.

By contrast, in the other two projects there was a strong reliance on international expertise and learning partnerships that have taken us through the different prototyping phases. We took advice from whoever wanted to give it to us. We embedded it into what we needed to do. We also decided not to build the SKA on our own. We are part of an international partnership, where we contribute roughly 14% of the funding, but the other 86% comes from the rest of the world. We've operated on that formula from the beginning. We understood that we can't do the whole thing, but we can join a larger partnership which can achieve more.

**AH: Since you wrote and published the paper [in *Social Dynamics*], have you had thoughts about other things that you would want to have drawn on as lessons from your experience?**

RA: Yes, one in particular, the National Ventilator Project.[6] This is a project which sits under the Department of Trade, Industry and Competition. Around the beginning of the Covid-19 pandemic, in April 2020, Minister [Ebrahim] Patel (who's the minister of that portfolio), was seized with the notion that we needed to have capability in South Africa to make ventilators.

He has been a fan of the SKA project for a long time. He came to me, together with Bernie Fanaroff who's my predecessor, and said 'Rob can you project manage to create very quickly a project to make ventilators, lots of them, for South Africa. Because we know that we're going to be in trouble in a couple of months' time'.

So I said yes, and people said to me, 'but you guys are astronomers. You built a telescope. Now you want to make ventilators?' And I said to them 'my insight into this thing is that the team, the engineering team, that we've put together can aim itself at almost any engineering problem.'

Obviously, we recruited doctors onto the team to tell us what was required, and we bolted other elements onto the team so we were able, in a couple of months, to go from knowing absolutely nothing about ventilators to building 20,000 of them.

And the lesson there was if you've got a strong balanced team, with systems engineers, mechanical engineers, different specialists, then your competitive advantage lies in maintaining the team rather than changing it for each project. You need to get the best people and build around those people, rather than change the people when you get a different challenge.

REFERENCES

Adam, R. M. 2020. 'Technology, policy and politics: critical success factors in high-technology infrastructure projects.' *Social Dynamics*, 46: 3, pp 378-390, DOI:10.1080/02533952.2020.1850619 (Open Access article).

Notes and Cloud Recording – from GPP5011F Lecture 17: 'Technology, Policy, and Politics,' Nelson Mandela School of Public Governance, University of Cape Town, master's seminar, 21 May 2021, led by Alan Hirsch and Rob Adam.

ENDNOTES

1. The mission of the Nelson Mandela School of Public Governance, based at the University of Cape Town (UCT), is to promote and inspire strategic public leadership in Africa. As a multi-disciplinary centre, the School and its offerings are designed to make public service at the highest levels of leadership an inspiration for the most talented of the community's rising generation. For more information, see http://www.mandelaschool.uct.ac.za/
2. See https://www.sarao.ac.za
3. This was Alec Erwin, Minister of Trade and Industry, 1996 to 2004, and Minister of Public Enterprises until September 2008 when President Thabo Mbeki stepped down.
4. A 20MW pool research reactor at Pelindaba, named SAFARI, was donated to South Africa by the US in 1965 as part of the 'foreign research reactor' programme. It used high-enriched uranium as fuel.
5. Savannah River Site (SRS) is a US Department of Energy facility for used nuclear fuel in South Carolina.
6. In mid-2020, the South African Radio Astronomy Observatory (SARAO) was mandated by the Department of Trade, Industry and Competition (DTIC) to manage the process for the National Ventilator Project. See https://www.sarao.ac.za/request-for-information-in-support-of-the-national-ventilator-project/ NA