

# Caveat Emptor

## CAVEAT EMPTOR

The Submarine Institute of Australia has asked me to share my 10 years of experience on the *Collins* class build program that I led until the Commonwealth nationalised the shipyard in 2001. I have agreed to speak because I am as anxious as all of you would be to see that the RAN acquires the best diesel-electric submarines at an acceptable whole of life cost. While the three contenders for the Future Submarine Program (FSP) - TKMS of Germany, DCNS of France and Mitsubishi-Kawasaki of Japan - possess acknowledged submarine design and building capability, carrying out the work in Adelaide sits outside their experience envelope. Designing and building the most advanced conventional submarine class in Kiel, Cherbourg or Kobe is a vastly different than performing this work in Australia.

Today I want to briefly present some facts that the Project Office and the Competitive Evaluation Process (CEP) contenders may find useful in their deliberations. My main concern is that more attention be paid to quality control, which would cut immediate costs and save the Navy from unexpected expenditures following commissioning. In particular I want to draw attention to the quality issues that ASC experienced with its overseas suppliers.

I believe that much of the current debate remains ill-informed. Knowledge of how the *Collins* project was constructed is still deficient. There is little real awareness of the actual problems or costs of undertaking such big defence projects, and with the changed industrial context since the 1990s it is unlikely ever to be acknowledged.

I will ignore the US-supplied combat system which had not attained full fit-for-purpose accreditation by the time all six submarines were commissioned into the navy in 2003.

But first, I believe, it is useful to understand the contract value at issue for the FSP. The media and some politicians are trying to outbid each other as to the delivery cost of 12 new ocean-going submarines. Sums of \$30 to \$50 billion dollars are bandied around by people with little knowledge or understanding of the scope of the work for the delivery of the FSP.

ASC delivered the six *Collins* class boats at roughly \$5 billion Australian dollars. The lump sum price included the establishment of a new, purpose-built, shipyard near Adelaide, the design, procurement and development of the combat system and the construction of the submarine platforms. It also included the training of personnel, the development of a Logistics Management System (SIMS/SIS), and the qualifying of some 1500 Australian sub-contractors to the then current Australian AS 3901-1987 Quality Standard.

By extrapolating the contract price for the six *Collins* class boats it would be safe to deduce that the \$50 billion price-tag the media attaches to a 12-boat FSP is way off the mark.

If the Commonwealth confirms an order for 8 + 4 long-range blue-water submarines of advanced, multi-purpose, capability, a unit cost of \$1.6 billion Australian dollars in today's money and exchange rate should be a more realistic figure. This number should also hold reasonably firm if the government pursues a single-source selection process for the new submarine class provided the RAN specified operational capabilities are not required concurrently. In other words, mine-laying, ROV, and Special Forces deployments, or torpedo and rocket launching capability are not required collectively on each mission.

My second point is this. Australian manufacturing capability is in much worse shape than even twenty years ago. I entered the submarine business with experience in building offshore oil and gas production platforms. The *Collins* project was then seen as part of a vibrant industry with the prospects that even higher-grade work could be taken on in the future.

But since that time heavy engineering industry has virtually ceased to exist in Australia. So there is less existing national capability to build on and much less hope for future work using newly developed skills.

As a result — while a capable domestic submarine and naval shipbuilding and repair industry is still clearly an important strategic asset to our defence capabilities — the national economic benefits or otherwise of a local naval shipbuilding industry are not so clear.

Having said that, there should be no argument about the considerable benefits the construction of future naval shipbuilding would bring to the South Australian economy. In fact with this work in S.A. the state may well secure a higher proportion of future defence work because of the general decline of Australian heavy engineering capability.

ASC was able to record greater than 70% local content for the submarine platform construction and approximately 40% for the delivery of the combat system. We could do this because in the *Collins* class contract **Australian Industry content was defined as work performed by an Australian company or business that was incorporated in Australia.**

Hence, under this broad definition work undertaken overseas was classed as local content where the supplier operated through an incorporated Australian company. The same rule applied to imported materials and sub-assemblies where the ‘importing’ entity was an Australian incorporated enterprise.

Thus, excluding the cost for imported materials, sub-assemblies and complete systems, the local content for work performed by ASC was merely 17.7%.

It was only after fully accounting for the supply of locally produced steel, GRP composites, batteries, painting, pumps, valves, forgings, anechoic tiles, fire-fighting equipment, the assembly of motors, generators, diesel engines, stern and torpedo tubes, all of which actually had some overseas content, did the *Collins* class approach 40% local content, well short of the claimable 70% under the contract.

**[FIG.1]**

While ASC has established a reliable supply chain for its submarine maintenance activities, accelerating globalisation and the subsequent decline in Australian manufacturing capabilities means the local content performance achieved on *Collins* will be even harder to meet on the FSP.

I cannot see — for instance — how high tensile hull plate, stainless steel pipes and fittings, diesel engines, propulsion motors, generators, motors, Li-ion batteries for submarine application, can now be procured other than by importation.

Returning to the strategic argument, I believe that the Navy should not remain silent in the domestic or overseas building debate. The RAN would be only too aware that the new class of submarines and ships must meet the current and the future demands of a dynamic, politically complex region, and that this requires ownership of unimpeded access to the submarine platform and combat system design.

The capacity to respond to unforeseen expeditionary requirements and achieve battle-readiness for an unlikely continental conflict can only be built on an effective domestic naval design and

shipbuilding capability. Our defence force must also have access to year-round availability of naval shipyards with a skilled workforce and a reliable and robust support capability during the life of a class. Even just assembling the submarines in Australia from imported systems would help provide these necessary domestic capabilities.

I now want to spend some time on the subject I feel most strongly about, and which has been almost totally ignored in the public debate so far.

The *Collins* class build program is an achievement that is unrivalled in modern Australian industrial history. It is a success story that could have gone drastically wrong if it had not been for the investment of the emotional, physical and intellectual energy of Australian and international participants in the program — drawn from both the private sector and government. It was this commitment that ensured that this complex program would not follow the fate of other submarine projects around the globe that were either abandoned or delivered years late and way over budget.

With hindsight, of course, the *Collins* class design and building contract could also have been delivered more efficiently, with fewer performance deficiencies and in a shorter time frame.

Better QC resources at suppliers' premises would have achieved a better outcome, and this is a central requirement to getting the FUTURE SUBMARINE PROGRAM right. While ASC gained Defence Quality Accreditation under AS 3901 in 1992, a tight delivery schedule required that the company proceeded to qualify vendors and subcontractors shortly after contract award in 1987. The overseas suppliers and subcontractors performed work largely in compliance with the KAB specification and to the QA and QC system of the respective prime contractors.

Regrettably the overseas vendors and manufacturers did not perform their work in accordance with the Australian Quality Standard, nor did ASC's quality management team seem able to gain sufficient transparency into the overseas suppliers' quality systems. This did not improve after ASC replaced its Defence second party with third party QA accreditation to the ISO 9001-1994 quality standard for ship design and construction.

Notwithstanding that the International Standard provided greater transparency, ASC continued to rely on the certification of the European suppliers to BS 5750-1979 or European equivalents, and US suppliers to the U.S. Mil-Q-9858a-1963 requirements. Hence the diverse quality cultures and the application of several quality standards led to the frequent discovery of defects throughout the program.

A notable example of overseas quality problems were the **Section 300 and 600 weld defects**, which for the first submarine were fabricated in Sweden where ASC relied on KAB's internal QC system which proved inadequate. Lots of boxes were ticked in a well-defined QC process, but copious minor defects were ignored or overlooked.

Another case of insufficient quality control was in the manufacture of **Trelleborg hoses**. Exhaustive testing by DSTO of a burst hose incident on the *Dechaineux* auxiliary seawater cooling system concluded that a fault had been introduced in the manufacture of that particular hose. Related to this near catastrophic situation was the lack of QC oversight by the submarine designer, which should have found that the effects of a 'double-ended' flood were not factored into the design.

The **Sonoston propeller** cast by Stone Manganese in the UK initially and then by Timcast was a case in point where ASC and KAB had very little oversight of the manufacturing process or

inspection of the finished product. Only after delivery were differences found between the propeller shape and the CAD drawings.

The saga of the **Hedemora** quality issues is public knowledge. The details of badly finished crankshafts, gear boxes and other appurtenances by the diesel supplier's subcontractors may be less well known. This case proves that a factory acceptance test of the end product – in this instance the submarine diesel engines – does not provide sufficient evidence that the product is reliable.

There were also issues with the main propulsion motor and generators manufactured by **Jeumont-Schneider** and subcontracted by the company for SM 02 - 06 to Westinghouse in Sydney. For the generators to operate continuously at +120°C, the bundled canes required greater spacing for heat dispersion. In this instance the OEM drawings provided to Westinghouse were not specific on bundle clearances, and there was insufficient QC from the OEM to have them built as per the French generators.

Belief by KAB, ASC and the Project Office that the main motor had had sufficient sea-time on French and other submarines, I believe, led to complacency.

After several years of in-service operation the fiberglass bands that constrain the main motor windings became brittle. ASC and the Defence Science and Technology Organisation (DSTO) identified this safety-critical problem as much a design deficiency as it was a manufacturing issue.

By constructing a full-scale mock-up of the motor, ASC and DSTO developed an optimal solution that should last the life of the class. It was a highly successful albeit expensive fix that could have been avoided by not readily accepting equipment solutions that are no longer in service with the parent navy.

Another major problem was an excessively leaking **propeller shaft seal**. The warranty claim on the manufacturer was unsuccessful because the German firm had gone out of business shortly after the delivery of the sixth seal.

The manufacture of **NiAlBr Stud Standpipe Adaptor couplings** were contracted to a UK supplier. After installation water ingress contaminated the hydraulic systems due to faulty material used for the manufacture. Quality inspected NiAlBr couplings also failed with tensioning during installation. Thus all free flood space weapon hydraulic system couplings had to be removed and replaced. Again, while the bar-stock were supplied with the specified quality documentation the problem could have been averted with a more effective quality control system.

ASC procured **Type 254SMO** high-alloy austenitic stainless steel pipe from the Netherlands. The supplier had the required quality accreditation and the pipe was supplied with the NDT as specified by ASC and KAB. However, during fabrication the longitudinal seam welds of the pipes were identified as defective and a costly replacement of all seamed pipe on the class had to be undertaken.

Non-metallic inclusions were also found in the bar-stock supplied for the manufacture of **Nuts and Bolts**. Typically these fasteners were delivered with certificates of compliance and other relevant quality documentation, incorrectly attesting to their compliance. In this regard it is my understanding that ASC has currently accepted Electric Boat's recommendation to double check certificates of compliance provided by suppliers, and on issues of SUBSAFE and safety critical items to carry out additional QC testing after receipt of goods.

And as a final example, corrosion problem with the **Nickel-plated hull valve forgings** affected all submarines. Kockums believed that the nickel-coating design was acceptable, and that the problems stemmed from a flawed manufacturing process by Australian Defence Industry (ADI). The first boat-

set was produced in Sweden by the proprietary 'Veralit' process. This technology was transferred to ADI of Bendigo for the manufacture and coating of all hull valve forgings for SM 02 - 06.

However, the higher salinity and water and air temperatures in the Pacific and the Indian Ocean led to accelerated corrosion on all boats. ASC instigated a design change with the approval of Kockums to replace the nickel-plating with Inconel-cladding across the submarine fleet.

**The problems I have identified here are not first-of-class problems.** The shipbuilding, aircraft and construction industries are littered with entirely avoidable quality issues of which the O-ring failure that caused the 1986 Challenger space shuttle disaster would be the most graphic example.

All three contenders for the FSP will probably argue that their supply chain has withstood the test of time, and the quality problems experienced during the *Collins* class build would not have happened on their watch. Kockums argued along similar lines. And the Project Office was comfortable with this arrangement because it considered KAB the most knowledgeable contractor available.

But with nearly all offshore equipment and material suppliers, ASC and KAB struggled to achieve sufficient oversight of equipment manufacture. While ASC QC representatives were present to sign off on many delivery programs, they had limited exposure to the manufacturing process. Similar problems, I believe, have bedevilled other Defence programs and to a much greater extent.

If we bring all this together we recognise that much more of the *Collins* work was performed overseas than is usually acknowledged; and that many of the problems with the class were from imported material, deficient OEM QC, and insufficient OEM technology transfer. It is also certain that the FSP will have to rely even more than the *Collins* program on the quality of imported systems, no matter what may be claimed by the builder of the future Australian submarine about their percentage of local build.

This means the most important part of local participation must be rigorous quality control management by an **independent program manager** who is charged by the Project Office with insuring that all program risks of resourcing, procurement, cost, schedule, and quality are identified, reported and mitigated.

The Construction Industry Institute of the US commissioned The University of Texas at Austin to produce a quality control manual called **Achieving Zero Rework through Effective Supplier Quality Practices [FIG.2]**. In the aerospace and shipbuilding industries, the Supply Quality Surveillance (SQS) programs prescribe a proactive approach to developing successful partnerships. The US industry's QC manual deals with the issues that I have referred to as follows:

*'The shipbuilding industry depends on a global supply chain of suppliers to prevent loss of valuable quality-related information about the final product, and the primary parties must maintain proper communication and complete information exchange during the product life cycle... Owner representatives execute SQS activities at supplier's facilities to exercise the right to surveillance and review of goods, procedures, and practices. The key to this exercise is in the execution of the supplier quality plan. This plan is developed early in the process and agreed to by all parties involved to ensure quality parts with zero defects'.*

While ASC and Defence have introduced the Product Life-cycle Management (PLM) platform software of Dassault-Enovia and Siemens PLM Software\* to provide authorised users with access to submarine and surface ship specifications, drawings and documents at their desktop, considerably more is required.

The US Construction Industry Institute is made up of a most sophisticated group of client agencies – including the who's who of hydrocarbons, power generation and the US Department of Defence Army Corps of Engineering.

In Australia, Defence still seems to shy away from interacting and sharing experiences with non-military industrial establishments. I think that there is much value to be gained if the FSP management team and the CEP contenders study the reports from the Construction Industry Institute.

Now that the political debate has shifted Canberra's and therefore the RAN's view firmly toward a domestic submarine build program, the contenders, TKMS of Germany, DCNS of France, and of late Mitsubishi and Kawasaki of Japan, have become unanimous in their view that building the future submarines in Australia is a prerequisite to winning the coveted multi-billion dollar contract. And ASC is now regarded by all three contenders of having the essential naval building capability that will deliver the future Australian submarines at the highest quality standard.

But for the complex and critical FSP with a global supply chain, reliance on the builder, suppliers and sub-suppliers to satisfy the quality standards specified for the project is not good enough. Quality control needs to go much deeper.

The appointment of an experienced, professional Project Management Contractor, will best ensure that the quality management deficiencies that bedevilled the *Collins* program are avoided [FIG.3].

The Project Manager would develop a comprehensive Quality Management Plan for the FSP involving inspection and acceptance at source, and thereby minimise the risk of costly rework, schedule delays and budget overruns.

**Caveat Emptor — Let the Buyer beware!**

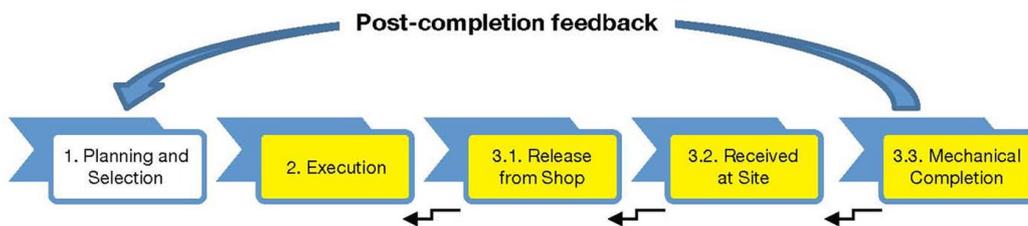
The award of the FSP contract will be celebrated with Champagne, Beer and Schnaps, or Sake; but it will end in a hangover if the lessons of the *Collins* class and more recently the AWD are not heeded.

[FIG1]

Contract C218269 ASC Collins Class Submarines Performance Report (A\$ x 1000)				
Organisation and Location	Scope of Work	June 1986	Dec. 2001	%
BHP - Bisaloy Steel - Pt Kembla	Normalised high-strength hull plate	31,916	32,587	0.65
ASC - Osborne yard, Adelaide	Project management & engineering support	168,030	286,944	5.74
	Submarine fabrication	103,696	250,425	5.01
	Integrated Logistic Services (ILS)	34,935	69,507	1.39
	Integrated Test & Trials (ITT)	19,015	32,336	0.65
ASC Eng. - Gepps Crs, Adelaide	Platform fabrication	45,763	48,339	1.93
ASC Shipbuilding - Carrington	Section 100 & 300 fabrication	24,622	25,834	0.52
Chicago Bridge & Iron (CBI) Syd.	Hull forming & fabrication	48,479	48,907	0.98
ADI - Garden Island & Bendigo	Appurtenances	9,391	9,556	0.19
Perry Engineering - Adelaide	Platform & section 300 & 600 fabrication	32,564	38,983	0.78
Futuretech	Platform Training Development	21,329	21,342	0.43
Total assembly including minor material supplies				17.61
Steelglow - Adelaide & Newcastle	Painting	10,120	25,430	0.51
Pacific Marine - Adelaide	Main submarine batteries	84,342	90,133	1.80
Buchanan Advanced Composites	GRP Casings	13,595	14,105	0.28
Comsteel	Hull forgings	11,474	11,474	0.23
Wormald - Sydney - Adelaide	Halon/AFFF fire-fighting, STSSF	21,932	21,985	0.44
Local content including semi-finished goods and third-party supplies				3.26
KABDES - Malmö - Adelaide	Design	191,675	216,325	4.33
British Aerospace	Diving & Safety Consoles	8,358	8,559	0.17
Singer - Link Miles	Platform Training Simulator	25,233	25,187	0.50
Strachan & Henshaw	Torpedo discharge system SM 01-06	195,452	211,600	4.24
Strachan & Henshaw	Torpedo handling system	21,390	21,426	0.43
VEEM Engineering - Perth	Worcester hull valves, actuators	17,200	17,200	0.34
MacTaggart Scott - Syd. - Adelaide	EPU, hydraulic actuators	9,131	9,129	0.18
MacTaggart Scott - Syd. - Adelaide	Towed array handling system	8,849	8,697	0.17
MacTaggart Scott - Syd. - Adelaide	Spears buoyant wire antenna & winch	4,447	4,236	0.08
SAAB - ASC	ISCMMS	116,851	119,782	2.40
Hedemora - ADI - Sweden - Sydney	Diesel Engines	28,117	28,286	0.57
Westinghouse (USA) - Sydney & Jeumont Schneider - France	Propulsion motor & generator SM 02-06	121,944	124,985	2.50
Total local content including semi-finished goods & overseas work				16.53
Euroatlas - Bremen	Power conversion equipment	27,433	27,563	0.55
KAB-Fabrication - Malmö	Section 300 & 600 fabrication SM 01.	88,534	89,225	1.79
KABCon - Malmö	Diving & Safety Consoles	6,368	6,255	0.13
Marconi Underwater Systems - UK	Communication Masts	17,112	17,212	0.34
Marconi Underwater Systems - UK	Pressure hull penetrators (PHP) & Longitudinal section joints (LSJ)	11,145	11,282	0.23
Marconi Underwater Systems - UK	Acoustic windows	11,340	11,259	0.23
Marconi Underwater Systems - UK	Degaussing equipment	8,772	9,835	0.20
Riva Calzoni	Mast hoisting system	61,558	61,558	1.23
DMT Marinetechnik STN-AEG	DC-motors, pumps & drives	14,236	17,259	0.35
Electro Navale, STN-AEG	DC-motors & chilled water pumps	13,941	13,536	0.27
BICC - UK	Electric cables	13,941	13,536	0.27
Rockwell Collins - Germany	External & internal communication systems	32,584	37,537	0.75
Sundry vendors & subcontractors		243,100	448,605	8.98
Total direct cost		1,965,973	2,574,425	51.53
Indirect cost.		415,290	1,114,311	22.30
Rockwell - Singer Librascope - CSC, Boeing	TDHS, processors, consoles, monitors, radar, sonars, periscopes, simulator software, etc.	987,737	1,209,638	24.21
Contract contingencies		523,000	98,000	1.96
Total Government Approved SEA 1114		3,892,000	4,996,374	100.00

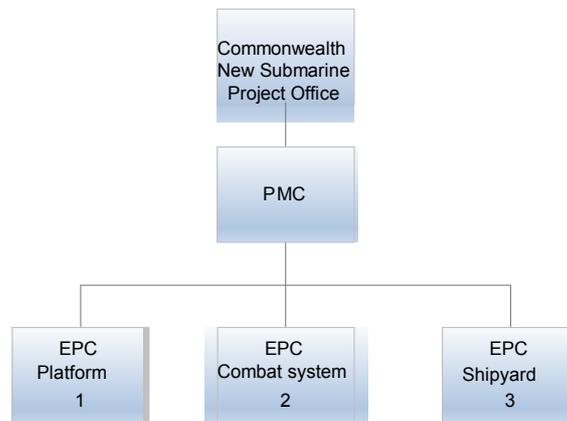
[FIG. 2]

# Achieving Zero Rework through Effective Supplier Quality Practices



[FIG. 3]

## Program Management Contracting (PMC)

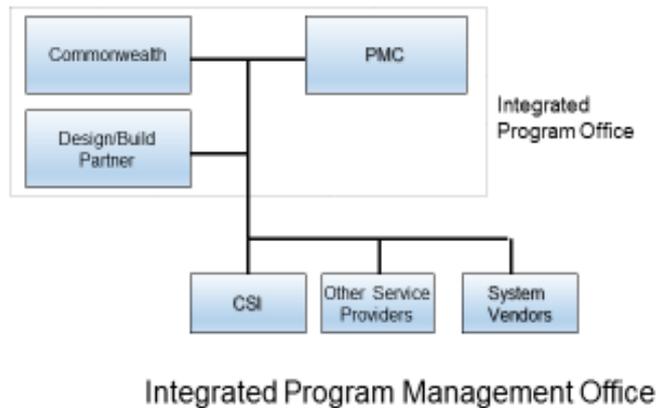


Typical PMC Structure

## Program Management Contracting

- **Corporate backing with staff possessing broad set of skills, including engineering, commercial and business qualification;**
- **Full suite of program management capabilities – people, process, systems;**
- **Local and global supply chain and SME networks;**
- **Global reach for the provision of local QC resources at suppliers premises**
- **Strategic relationships with key Australian, European, USA, and Japanese industries;**
- **Delivery assurance through corporate experience and lessons learnt on complex mega-programs;**
- **Engineering management capability – including platform and systems integration in both the design and build phase;**
- **Complex asset fleet sustainment methodologies;**
- **Proven HSE culture and commitment;**
- **Proven record of driving efficiency, innovation and successful outcomes**

## Collaborative Defence-Industry Approach



## Quality Assurance (QA) vs Quality Control (QC)

- QA is a process driven and QC is product driven system
- QA must provide the confidence that quality is meeting specified requirement
- Testing is done at the material, component or equipment level and thus is in a QC domain
- Testing for quality goes beyond assuring that a quality system is in place - it directly controls the quality of the product
- QC ensures the results of what is done is what is specified