PART 1:
THE MEGAPROJECT PARADOX

WHAT IS THE PROBLEM WITH MEGAPROJECTS?

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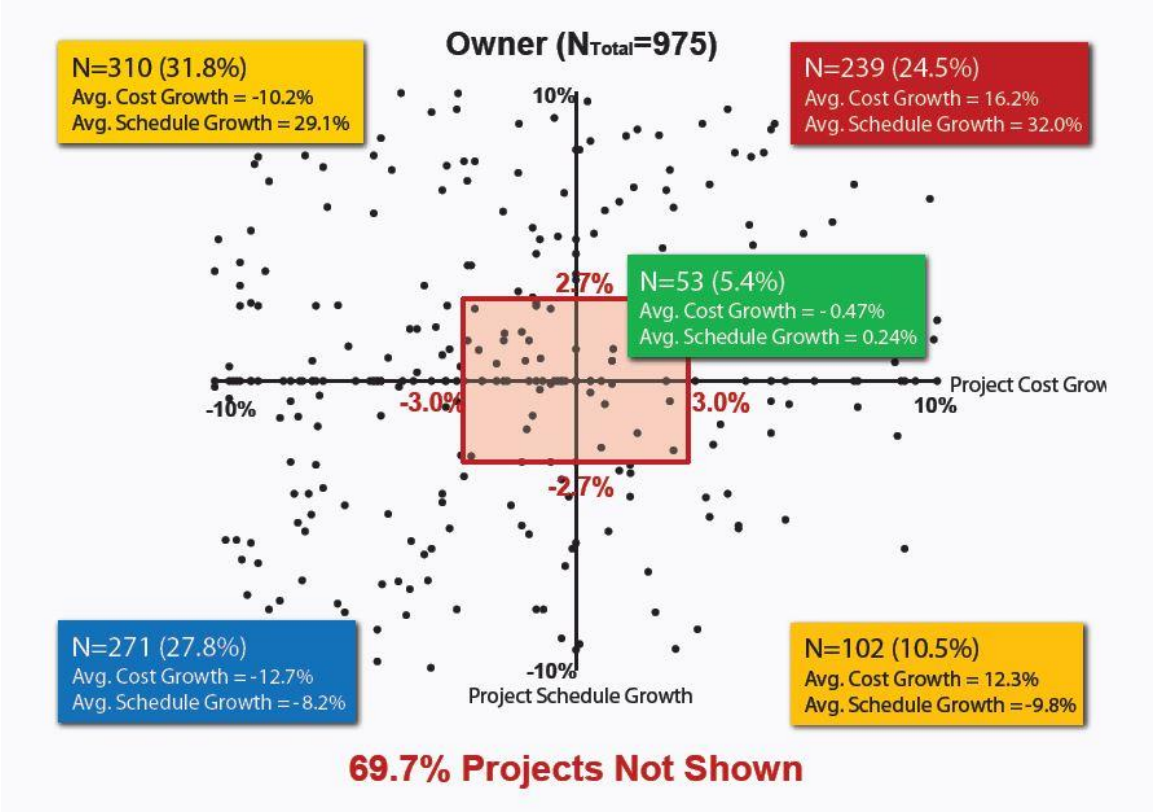
PART 1: THE MEGAPROJECT PARADOX
WHAT IS THE PROBLEM WITH MEGAPROJECTS?

This series of articles is designed to assist "*Owners*" of Megaprojects with some historical Megaproject "*Lessons Learned*". The lessons come from experience across the "*Life Cycle*" of some of history's most complex and sophisticated Megaprojects. The fundamental "*Lesson Learned*" is that "*Owners*" consider a Megaproject achieving successful Execution only if "*predictable simultaneous achievement of Project Cost and Project Schedule*" is achieved in the Execution Phase. The "*Megaproject Paradox*" articles are focused at helping Megaproject "*Owners*", and therefore the Non-Owner Supply Chain involved in a Megaproject, move the needle from the position of 95% level of failure of Megaproject predictability back towards 0% failure of Megaproject predictability.



Data considering 975 different Megaprojects from around the world compiled by the Construction Industry Institute (CII) in its 2012 Performance Assessment Report shows 95% of Megaprojects fail to achieve the "*Owner's*" benchmark for successful Megaproject predictability in the Execution phase of the Megaproject "*Life Cycle*". The CII chart shown above identifies the 5.4% of successful Megaprojects in the "*Pink Box*", defined by the "*Owners*" of the 975 Megaprojects. The 95% failure to execute as predicted by the owner is "*The Problem with Megaprojects*". The "*Megaproject Paradox*" is a term created to highlight how counter intuitive it is that 95% of Megaprojects fail to achieve the "*Owner's*" benchmark of "*predictable simultaneous achievement of Project Cost and Project Schedule*" in the Execution Phase.

Megaprojects attract massive, almost unlimited investment in time, money and high quality man hours by the biggest and best Owner Companies and Non-Owner supply chain during the Execution of a Megaproject. Despite that investment by those companies, the 95% failure rate defines the "*Megaproject Paradox*".

The "*Megaproject Paradox*" series of articles explores reasons why the "*Megaproject Paradox*" is so predominant. A structured method called "*The Noonan Method for Megaproject Risk Mitigation*" is introduced to the Megaproject supply chain. The "*Noonan Method*" enables "*Owners*" to identify, negotiate and avoid or overcome the barriers presented by the "*Megaproject Paradox*. The "*Megaproject Paradox*" series of articles are designed to introduce "*Owners*" to "*The Noonan Method for Megaproject Risk Mitigation*" and help them prepare for and plan to mitigate the risk and avoid the "*Megaproject Paradox*" occurring in any type of "*Owner's*" Megaproject, or Portfolio of Megaprojects. In cases where "*Megaproject Paradox*" issues already exist or are looming within a Megaproject, the "*Noonan Method*" offers "*Owners*" a new method to address and overcome "*Megaproject Paradox*" issues in the least complex and most cost-effective way.

1.1 WHAT ARE MEGAPROJECTS?

Megaprojects are typically considered to be highly complex, time consuming and costly infrastructure developments. Megaprojects are typically so complex that even the people involved in the Megaproject Supply Chain find the Megaproject incredibly difficult to appropriately understand and describe well enough to execute predictably as planned by the "*Owner*". In this series of articles, the concept of Megaproject "*Parameters*" is introduced to enable the supply chain to consistently, fully and accurately describe and govern a Megaproject of any type. Using "*Megaproject Parameters*" a new process applied to a Megaproject's "*Organisation*" is introduced. The process of "*Organisation Design, Modelling, Simulation, Analysis and Verification*" prior to deployment of the Megaproject "*Organisation*" is proposed.

This new process is used to identify, negotiate, and avoid or overcome "*Megaproject Paradox*" issues, across the "*Life Cycle*" of a Megaproject. The process uses the "*Parameters*" as input to Monte Carlo simulation algorithms and other modelling techniques as a method to provide 20/20 foresight into the analysis and ultimate verification of predictability of "*Organisation*" performance prior to deployment.

Real world examples of Megaprojects include among other infrastructure:

- **Civil:** Bridges; Tunnels; Highways, Roads, Freeways, Tollways; Railways; Airports; Sea Ports; Dams; Potable and Waste Water Projects; Large Scale Public Transportation Projects;

- **Construction:** Special Economic Zones; Hospitals; Prisons and other Public Buildings; Large Scale Sporting Infrastructure; Mixed use Waterfront Developments; Commercial Developments; Megacities;

- **Mining & Resources:** Underground and Open Cut Mines; Mineral Concentrate Processing Plant including Gas Plant; Port Mineral Circuits; Ore and Concentrate Transport and Storage;

- **Defence:** Space Systems; Airborne Systems; Naval Systems; Land Systems; Weapons/Combat Systems; Integrated Logistics Support Systems; Command, Control, Communication and Intelligence Systems; CyberSecurity Systems;

- **Education and Research:** Physics Fundamental Particle Research Infrastructure; Satellite Astronomy Research Infrastructure; Large Scale Terrestrial Astronomy Research Infrastructure; Earth Observation Research Infrastructure; Interplanetary Exploration Research Infrastructure; Geodesy and Materials Science Research Infrastructure; Atmospheric Science Research Infrastructure; International Space Station Research Infrastructure; Medical Research Infrastructure; Evolving Space Based Infrastructure including Space Elevators and Dyson Spheres;

- **IT & Telecommunications:** Air Traffic Control Systems, Commercial Television and Radio Broadcast Systems; The Global Internet; Internet of Things; Country wide Wireless and Wired Telecommunications; Data Centres; Global VPN's; Global IT&T Product Corporations (Hardware and/or Software); Integrated Circuit Fabrication Facilities; High Performance Computing System Installations; Autonomous Vehicle Systems; Sophisticated Corporate Software Product Development;

- **Energy:** Oil and Natural Gas Extraction Projects; Oil Refineries; Chemical and Gas Plant; Hydroelectric Projects; Nuclear Power and other Electricity Generation Projects; Electricity Transmission and Distribution Infrastructure; Renewable Energy Infrastructure including Solar and Wind Generation; National Electricity Markets; Electric Vehicle (EV) Manufacture; Sophisticated Battery Storage Manufacturing Facilities;

- **Manufacturing:** Iron, Steel and Ferro Alloy Production and Processing; Alumina and Aluminium Production and Processing; Non-ferrous Metal Production and Processing; Engine and Turbine Manufacturing; Power Transmission and Distribution Equipment Manufacturing; Earth Moving, Mining, Agricultural and Construction Equipment Manufacturing; Electrical Motor Manufacturing; Transformer Manufacturing; Generator Manufacturing; Vehicles and Commercial Ships Manufacturing; Aerospace Products and Parts Manufacturing; Locomotives, Railroad and Transit Cars, Light Rail and Rail Track Equipment Manufacturing; Medical and Pharmaceutical Product Manufacturing;

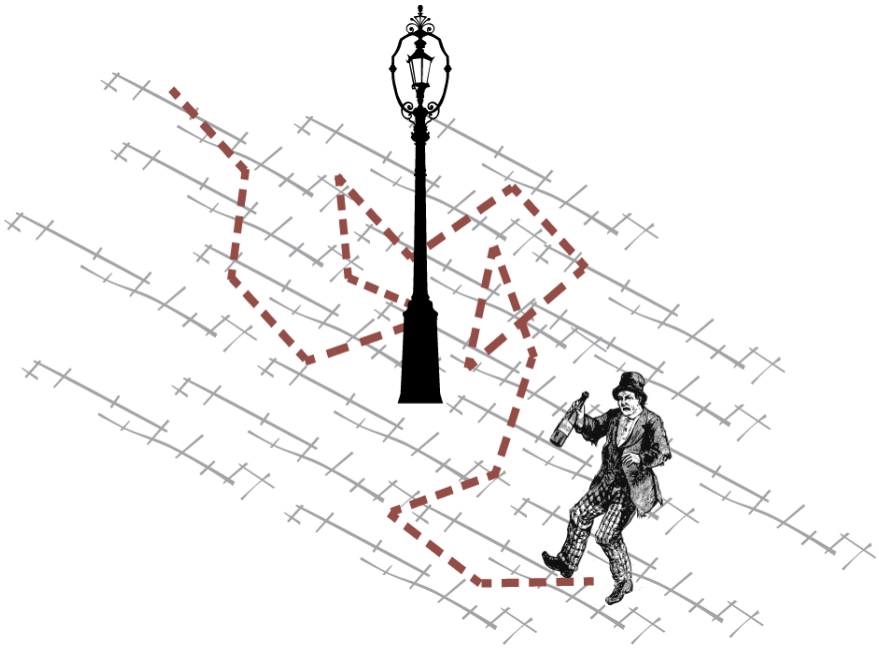
1.2 NOONAN METHOD FOR MEGAPROJECT RISK MITIGATION

The process of Design, Modelling, Simulation, Analysis and Verification ("*The Drunken Man's walk*") is well understood when it comes to engineering "*Technology Designs*". "*Owners*" through their Project Directors and Engineers would never consider commencing the Execution Phase of a Megaproject "*Life Cycle*", without spending appropriate time, often years, stepping through the Design, Model, Simulate, Analyse and Verify process in Preparatory Phases of the Megaproject "*Life Cycle*". Verifying a complex Megaproject design

in Preparatory Phases is required by Megaproject "*Owners*" as part of the due diligence required for the "*Final Investment Decision*" (FID) prior to entering the Execution Phase.

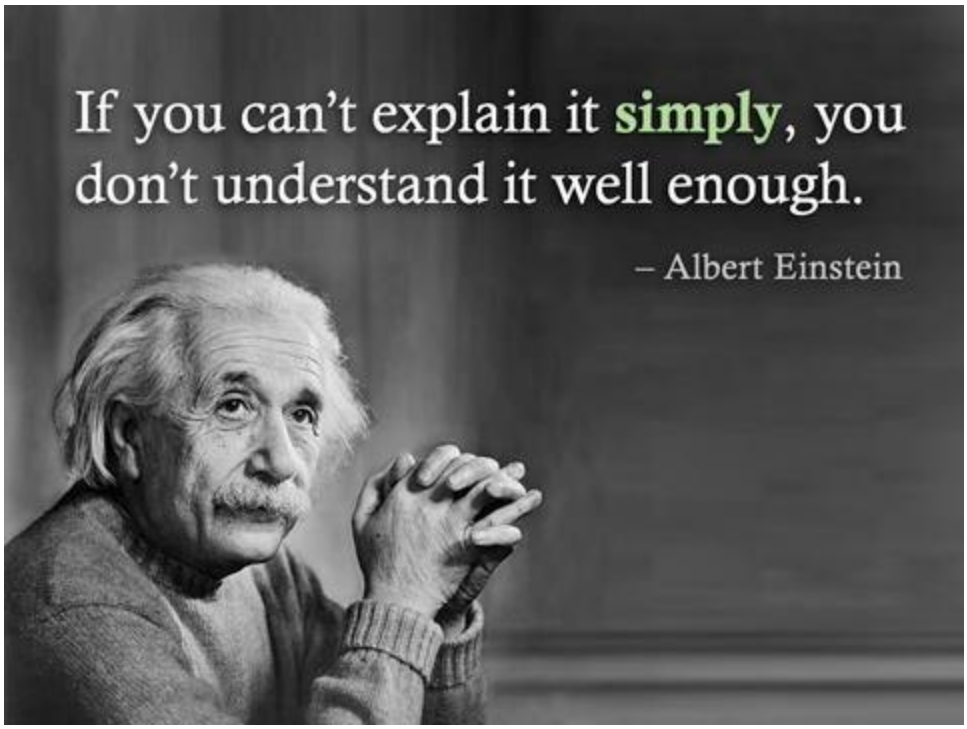
For complex Megaproject designs, the Design process is conducted at a high level in early Preparatory Phases, usually from an Architectural Design perspective. As an "*Owner's*" team progresses through the Preparatory Phases, Engineering design teams will drill down through the Design process to the greatest "*Design for Construction*" detail that is required to overcome any potential for construction or cost issues in the Execution Phase. The Design process is completed to a level of detail considered by the "*Owner*" as necessary to maximize the chance of "*predictable simultaneous achievement of Project Cost and Project Schedule*" in the Execution Phase.

The terms "*Basis of Design*" or (BOD) and "*Front End Engineering and Design*" (FEED) are often referred to in Oil and Gas Megaprojects as having to be completed to a satisfactory level before FID is taken. Only after FID is signed off, can the "*Owner*" of the Megaproject proceed into the Megaproject Execution Phase.



The "*Drunken Man's Walk*" is neither well understood nor used when it comes to applying the same due diligence to the Design of the "*Organisation*" involved in a Megaproject across the supply chain. This series of articles introduces "*The Noonan Method for Megaproject Risk Mitigation*" to redress this failure of due diligence in Megaproject Preparatory Phases.

The "*Noonan Method*" identifies a process of Designing, Modelling, Simulating, Analysing and Verifying the Megaproject Organisation before it is deployed at each phase of the Megaproject "*Life Cycle*". The "*Megaproject Paradox*" articles identify that with all "*Megaproject Paradox*" issues, one of the common denominators behind the issues are the "*People*". Identifying, and avoiding or negotiating and overcoming the "*People*" issues, and the process in doing so, is fundamental to "*The Noonan Method for Megaproject Risk Mitigation*".



The use of the Design, Model, Simulate, Analyse and Verify process for "*Technology Design*" is enabled by the use of sophisticated design tools that have been in use for around 30 years as of 2017. For example, "*Autocad/Revit/Inventor*" or "*Solidworks*" among other commercial offerings. These tools require defined "*Parameters*" to enable the Design process to proceed in both 2 and 3 physical dimensions. Automated tools link the Design process to the Modelling process. The Simulation process then enables variable parametric input to test the Model of the Design to analyse Design performance. For complex "*Technology Design*" typical in Megaprojects, numerous iterative cycles are required to step through the Design, Model, Simulate process before the Analysis of the Simulation results Verify whether complex technical designs are predicted to work. Only once the "*Technology Design*" is finally Verified to the required level of detail, can the Design process be considered complete enough for FID to be taken and the Execution Phase of the Megaproject be commenced with some confidence of predicted performance.

It is understood by "*Owners*" that the Execution Phase of a Megaproject will not be commenced before the "*Technology Design*" process has been "*Verified*" as complete to an appropriate level of detail. History shows "*Owners*" sometimes do initiate the Megaproject Execution Phase before the "*Technology Design*" process has been completed with Verification to an appropriate level of detail. "*Owners*" who do so are showing an intemperate approach to the Megaproject Preparation Phases and will guarantee the occurrence of the "*Megaproject Paradox*" in the Execution Phase.

History also shows that as of 2017, very few if any Megaproject "*Owners*" understand the need for, or use the same Design, Model, Simulate, Analyse and Verify due diligence process for the Megaproject "*Organisation*". This series of articles proposes that "*Owners*" who do not implement an appropriate level of due diligence in the "*Organisation*" Design, Model, Simulate, Analyse and Verify process will also guarantee the occurrence of the "*Megaproject Paradox*". The "*Megaproject Paradox*" series of articles associates the 95% failure rate of Megaprojects to perform as predicted by the "*Owner*", primarily to the lack of due diligence in the Megaproject "*Organisation*" Design process. The question may be asked, "*What is the secret behind the success of the 5% identified in the CII Graph*"? This series of articles proposes that the successful 5% are nothing more than statistical fluke.

1.2.1 NOONAN MEGAPROJECT PARAMETERS

"*The Noonan Method for Megaproject Risk Mitigation*" identifies the requirement for the use of appropriate "*Noonan Megaproject Parameters*" for the "*Organisation*" Design, Model, Simulation, Analysis and Verification process. There are two types of "*Noonan Megaproject Parameters*". The first type, detailed in this article, are used to accurately describe a Megaproject, and are therefore referred to as the "*Horizontal Noonan Megaproject Parameters*" or the "*Descriptive Parameters*". The second type of "*Noonan Megaproject Parameters*" are described in Part 4 of the series of "*Megaproject Paradox*" articles and are referred to as the "*Vertical Noonan Megaproject Parameters*" or the "*Rule Parameters*". These "*Parameters*" enable "*The Noonan Method for Megaproject Risk Mitigation*" to be applied to the Megaproject "*Organisation*" Design, Modelling, Simulation, Analysis and Verification process.

There are eight "*Descriptive*" or "*Horizontal Noonan Megaproject Parameters*". Those eight "*Parameters*" are first introduced in summary form, in order of priority of definition, as follows.

1. **OWNERSHIP**: The Construction Industry Institute (CII) identifies that despite the scale of investment in Megaproject Preparatory Phases due diligence, the quality of people involved in the Preparatory Phases of Megaprojects, there remains at least a 95% risk and liability associated with Megaproject Execution predictability using legacy approaches to Megaproject Preparation. Driven by Megaproject Financiers' and Insurers' desire to spread the 95% risk and liability of investment in Megaprojects, ownership is usually a shared responsibility between a number of large corporate and/or government partners. This risk and liability is in turn shared by "*Owners*" via an appropriate contractual instrument with the non-owner supply chain. Multiple Megaproject "*Owners*" are bound together through various legal instruments, some examples being Joint Venture Partnerships (JVPs), or Public Private Partnerships (PPPs), or Alliances, or a jointly share-held company between key owners and possibly even a key non-owner. Having multiple "*Owners*" of a Megaproject increases its complexity and contributes to the 95% risk of a Megaproject failing to achieve the "*Owner's*" benchmark of success, "*predictable simultaneous achievement of Project Cost and Project Schedule*" in the Execution Phase.

2. **LIFE CYCLE:** A **c**omplete Megaproject "*Life Cycle*" is typically measured by many decades or longer. A Complete "*Life Cycle*" has definitive phases of evolution including Preparatory Phases prior to Megaproject Execution, and Operations,

Maintenance and Closure post Megaproject Execution. Preparation for Megaproject Execution is referred to using different labels in different Industries. Preparation for Civil projects often refers to (i) Project Initiation and (ii) Project Planning. Oil and Gas Project Preparation typically refers to (i) Exploration and Production prior to, (ii) Basis of Design (BOD) leading to (iii) Front End Engineering and Design (FEED) leading to (iv) Final Investment Decision (FID), leading to (v) Execution. In the Oil and Gas Execution Phase terms such as Hookup and Completions prior to Startup, Commissioning and Acceptance testing mark the transition to (vi) Operations and Maintenance. Shutdowns of Oil and Gas Plant are usually referred to as (vii) Turnarounds.

For Defence Projects in Australia the Preparation Phase of a Megaproject is structured into two parts (i) a Needs Phase and (ii) a Requirements Phase. Preparation alone can last a decade or longer for a Megaproject and can cost more than $1 Billion. Examples of the scale and complexity of Megaproject Preparation will be given in this and other parts of the "*Megaproject Paradox*". As a rule, the larger a Megaproject, the longer and more costly will be the Preparatory Phases of work. The exception to this rule may be for example, Defence Megaprojects brought on by the urgency of war or other government mandated priorities.

Alternately competitive pressure brought on by commercial product opportunity and innovation may also impact upon Megaproject Schedule, for example the Tesla Gigafactory or Intel's Fabrication Plant. After the Megaproject Preparation Phase is completed to a sufficient level of confidence for the "*Owner*", FID is achieved and Megaproject Execution follows.

Individual Phases in the "*Life Cycle*" are also broken down into further sub phases. For example, Megaproject Execution is also broken into phases of work again defined differently depending upon which Industry the project falls into. The Execution Phases typically include (i) Procurement, (ii) Fabrication, (iii) Construction, (iv) Installation, (v) Hookup, (vi) Completion, and (vii) Start up. Megaproject work will inevitably be System Engineered into subsystems, with each subsystem undertaking its own Preparation and Execution Phases.

After completion of the Megaproject Execution Phase, the Megaproject moves into the Operations and Maintenance Phase of the "*Life Cycle*". Ultimately, after the Operations and Maintenance Phase concludes, Megaproject Closure marks the end of the "*Life Cycle*". The Megaproject Execution Phase is the focus of this and most of the following articles on the Megaproject Paradox. Examples will be provided of the application of the "*Noonan Method*" to Megaprojects in the Preparation Phase of the "*Life Cycle*", for example the Woodside BROWSE LNG Project, and Megaprojects in the Operations and Maintenance Phase of the "*Life Cycle*", for example the Australian National Electricity Market (NEM).

3. **COST:** Prior to 2000, a Megaproject was typically defined as a project costing in excess of $1 Billion. By 2017 the term Megaproject has arguably grown to define projects costing in excess of $10 Billion. Megaprojects develop an economy of their own once they enter the Execution Phase of the "*Life Cycle*" and are typically

insulated from regional or global economic fluctuations. While the "*Noonan Method*" is recommended for avoiding or resolution of "*Megaproject Paradox*" issues, it is also useful to avoid or resolve issues in Projects of smaller size where issues continue to survive and propagate due to complexity within Projects. Complexity is another common denominator in the occurrence of "*Megaproject Paradox*" issues. There are many examples of projects where complexity is extreme, and yet the "*Cost*" is less than $1 Billion.

4. **SCOPE COMPLEXITY:** The level of "*Scope Complexity*" of a Megaproject is considered extreme in terms of technical and human sophistication. The technical scope of a Megaproject necessarily engages a relatively massive "*Organisation*" (covered as a separate parameter here) across the Megaproject "*Life Cycle*" to execute the project to completion. "*Scope complexity*" is refined and expanded to a level of detail in the Preparatory Phases of the "*Life Cycle*". The level of detail required of "*Scope Complexity*" is sufficient to enable the "*Owner*" to predict with a high level of confidence, the "*simultaneous execution of Megaproject Cost and Megaproject Schedule*" in the Preparation Phase. "*Scope Complexity*" typically commences with a broad description of the Megaproject, examples provided in following sections of this article. The Preparatory Phases of the "*Life Cycle*" are then used to iteratively expand upon the detailed scope of the Megaproject to provide sufficient detailed definition of "*Scope complexity*" for the supply chain making up the non-owner team to execute the Megaproject.

   The level of detail required in "*Scope Complexity*" for FID to be taken by the "*Owner*" is sometimes measured using Monte Carlo type probabilistic evaluations for "*Cost*" estimates. Monte Carlo definitions of estimates such as P10, P30, P40, P50, or P90 will be used in some Megaprojects to identify level of detail in the estimation process during the Preparatory Phases. Estimates ranging from low level estimates being completed through to high level estimates being completed. P90 means 90% of the estimates exceed the P90 estimate. It does not mean that the estimate has a 90% chance of occurring – that is a very different concept. The central limit theorem indicates that the P50 estimate has more chance of occurring than the P90 and P10 estimates.

5. **CONTRACT:** Megaprojects are typically too big for owners to consider self-performing. Appropriate contractual instruments binding a non-owner supply chain to the owner are usually required. These contracts are typically complex and difficult to negotiate, operate and administer. Examples of appropriate Megaproject Relationship Contracts may be: (i) Engineering, Procurement and Construction (EPC) contracts, or (ii) Engineering, Procurement and Construction Management (EPCM) contracts, or (iii) Managing Contracts, or (iv) Alliance Contracts, or (v) Public Private Partnerships. Other appropriate contractual vehicles may be used particular to the location and type of Megaproject that is to be executed. For example, a jointly share-held company between key owners and a key non-owner execution partner. One key deliverable of the Relationship Contract must be the "*Owner's*" benchmark for success, "*predictable simultaneous achievement of Megaproject Cost and Megaproject Schedule*" in the Execution Phase.

6. **ORGANISATION:** The number of people involved in the Execution Phase of a Megaproject is often in excess of 10,000 across the Megaproject supply chain. The supply chain is driven by the "*Owner's*" team directing a non-owner team in some form of appropriate relationship contract. The non-owner team typically engages appropriate sub-contractors, vendors and suppliers in the supply chain to participate in the Megaproject Execution Phase on behalf of the "*Owner*". The entire complex and sophisticated supply chain must be focused on the "*Owner's*" benchmark for success, "*predictable simultaneous achievement of Project Cost and Project Schedule*" in the Execution Phase.

7. **GEOLOCATION:** The Execution Phase of a Megaproject is often globally engineered and fabricated with companies participating from around the world to execute the Megaproject. The Megaproject typically comes together through assembly, installation, hookup, completion, startup, commissioning and acceptance testing in one location. Hundreds of companies and thousands of people from around the world usually participate, often using "*modular*" fabrication techniques rather than "*Stick Built*" on site. Megaproject Executive Leadership Teams (ELTs) are consequently faced with complex "*Organisation*", communication and logistics issues. Issues include management and coordination of remote teams in different time zones, with different languages, and cultures among other issues. The "*Owner*" ELTs must manage these teams to meet the same owner benchmark of success, "*predictable simultaneous achievement of Project Cost and Project Schedule*" in the Execution Phase.

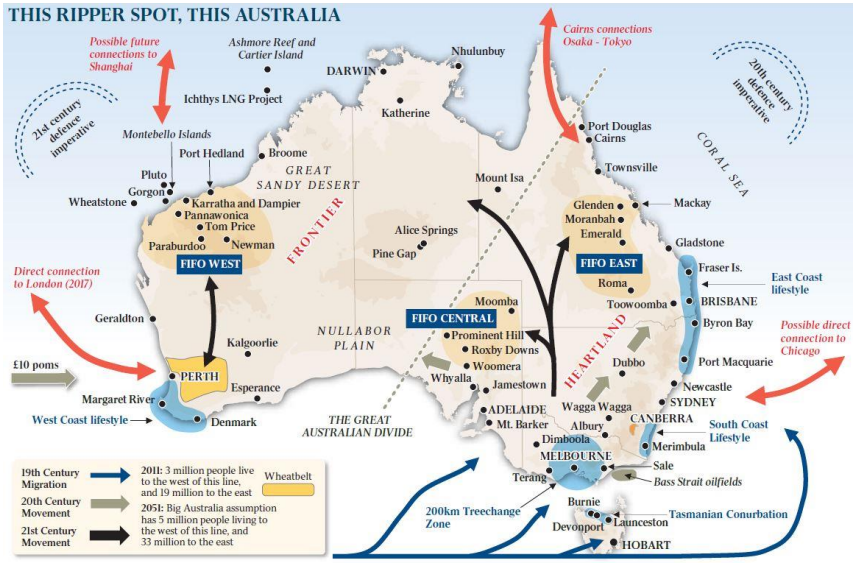
8. **RISK:** Despite the scale of investment in Megaproject Preparaton in both time and money, Megaproject Execution too often performs poorly in terms of the owner benchmark of "*predictable simultaneous achievement of Megaproject Cost and Megaproject Schedule*". The Construction Industry Institute (CII) reports that 95% of Megaprojects fail to achieve this goal. The 95% risk of simultaneous Cost and Schedule achievement in the Execution Phase, crystallises the "*Megaproject Paradox*" definition. Identifying, mitigating and overcoming this 95% risk is the topic of discussion in the various Parts of the "*Megaproject Paradox*". How can owners best mitigate risk and achieve simultaneous predictability of Megaproject Cost and Megaproject Schedule as estimated in the Preparation Phase of the Megaproject? Using 20/20 hindsight as a reference point, the Megaproject Paradox is studied using a detailed graphical analysis of 975 Megaprojects once Execution Phase is complete. The study was produced by the CII out of the University of Texas Engineering Faculty, Austin Campus, in their 2012 Performance Assessment Report. 20/20 Hindsight provides a great foundation for the Megaproject, but then leads to the logical requirement of 20/20 Foresight to plan the way forward. "*The Noonan Method for Megaproject Risk Mitigation*" aims to reduce the 95% risk of failure to Execute a Megaproject as planned by the "*Owner*" to a much lower risk level.

Theoretical application of "*The Noonan Method for Megaproject Risk Mitigation*" will be demonstrated in this article associated with a new Australian Defence Megaproject, SEA 1000. The analysis presented in this article is based upon public domain information. The SEA 1000 Megaproject defines the Australian Government strategy for the design and fabrication of 12 new submarines for the Royal Australian Navy.

1.3 PREPARING FOR DEFENCE MEGAPROJECT: SEA 1000

Prior to commencing the Execution Phase of a Megaproject, the "*Owner*" typically invests at least a decade or more in terms of time in the Preparatory Phases. The amount of capital invested in the Preparatory Phases is also significant and will often exceed $1 Billion. For the purposes of highlighting and understanding the complexity, scale and scope of work performed in Preparation for Execution of a Megaproject, the New Australian Submarine Project (SEA 1000) announced in April 2016 is a current and appropriate Megaproject to consider.

On 26 April 2016, Prime Minister Turnbull announced that the 6 Australian built Collins Class Submarines will be replaced by 12 conventional submarines based upon the Shortfin Barracuda Submarines designed by French Government owned Shipbuilder DCNS. Twelve conventional Submarines will be built, Operated and Maintained in Australia at a projected "*Cost*" of $50 Billion over a 50-year Life Cycle.



To minimise the risk of the "*Megaproject Paradox*" occurring, it would be best for the Australian Government to use the "*Lessons Learned*" at the ASC over the prior 30 years of its

existence and Execution of two Australian Shipbuilding Megaprojects, the 6 Collins Submarines and the 3 Air Warfare Destroyers. The 12 New Submarines should be designed and manufactured at Australian Submarine Corporation's (ASC's) Osborne facility on the Port River in South Australia as planned by prior Australian Federal Government bipartisan strategy.

As negotiations have progressed with DCNS subsequent to the April 2016 announcement, doubt remains as to the Australian Federal Government's ongoing support for the Australian Government owned Shipbuilder. ASC's involvement in the SEA 1000 Megaproject appears in doubt as of early 2017. It appears possible that the Australian Government's chosen international partner, the French Government owned shipbuilder DCNS, may replace the Australian Government owned Shipbuilder entirely for the SEA 1000 Megaproject. Should that strategy be implemented by the Australian Federal Government, DCNS will be faced with the recreation from scratch of the systems and processes developed over ASC's 30-year life cycle. DCNS in early 2017 is already expressing frustration at securing Australian Industry participation in the SEA 1000 Megaproject. This would not be an issue if DCNS was working with ASC and tapping into the ASC developed supply chain. The consequences for Australian Industry could be dire, as DCNS may use this as an excuse to suggest that the first New Submarine should be built in France.

The following public domain desktop analysis of the SEA 1000 Megaproject uses the "*Descriptive Parameters*" defined in "*The Noonan Method for Megaproject Risk Mitigation*". This analysis provides a sample scenario analysis in an effort to mitigate against the likelihood of the "*Megaproject Paradox*" occurring in SEA 1000.

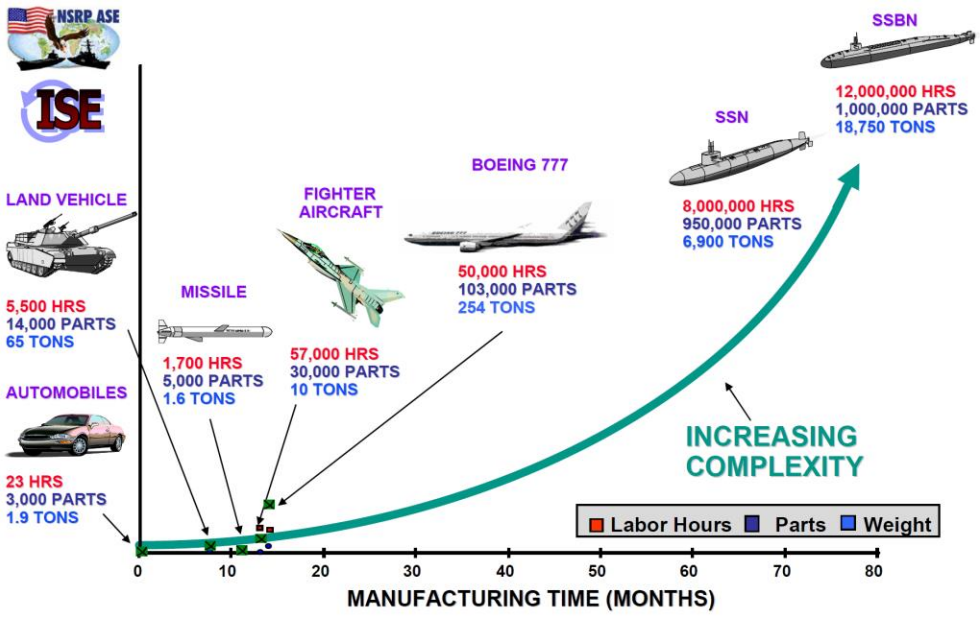
1. **Ownership**: The Australian Government is the ultimate owner of the 12 new Submarines which will be operated by the Royal Australian Navy (RAN). The Australian Government's historic execution vehicle for submarines is ASC Pty Ltd. The contractual instrument chosen by the Government to execute the Submarines with its chosen Design Partner DCNS remains to be decided and announced. Consideration as to the most appropriate ownership instrument will be informed by appropriate analysis

like that proposed in this article, but with all appropriate due diligence information available. Joint Venture Partnership (JVP) with DCNS has already been publicly mooted, but as of early 2017, it appears possible that the Australian Government may be in the process of dismantling ASC with a view to ensuring that it plays no role in the construction of the 12 New Submarines.

2. **Life Cycle**: If SEA 1000 was to use ASC, it could benefit from a 30-year preparation phase at ASC with Collins and AWD Megaprojects being used to develop a construction blueprint and "*Lessons Learned*" for both Submarine and Surface Ship construction in Australia. SEA 1000 could expect to spend up to two decades in the Execution Phase (Construction Phase), and at least 3 decades in the Operations and Maintenance Phase. The projected "*Life Cycle*" for SEA 1000 is in the order of 50 years prior to decommissioning of the 12 New Submarines.

3. **Cost**: The value of the SEA 1000 Megaproject as determined in the Australian DoD Preparatory Needs and Requirements Phases is expected to cost the Australian Government "*Owner*" AUS$50 Billion. This cost covers the Execution, Operations and Maintenance, and Closure Phases of the Megaproject Life Cycle.

4. **Scope Complexity**: Developing a sophisticated modern conventional submarine design by modifying a foreign partner's Nuclear Submarine design as a basis and constructing 12 new Conventional Submarines is complex. Integrating the latest sophisticated Combat and Weapons Systems from the US, and custom developed ILS Systems and Ship Control and Management Systems using the latest available technology for Australian requirements is as sophisticated and complex a shipbuilding task that humans can attempt. Submarine construction is generally considered second only in complexity to construction of a Space Shuttle.



5. **Contract**: The Relationship Contract binding the owner to the non-owner supply chain remains to be appropriately negotiated. The form of contract will depend on the form

of ownership relationship that is first determined. The Australian Government has two contract models that have been previously used at the ASC to consider. The prior shared ownership of the ASC acting as a Managing Contractor for the Collins Megaproject is one model for ownership. The Alliance Contract used for the construction of the AWD Megaproject is another model for consideration. "*Lessons Learned*" from the Execution Phase of both of these Megaprojects should be used to inform the Australian Government as owner, to the most appropriate contractual instrument to Execute SEA 1000.

One key objective of the Australian Government, as stated repeatedly by Minister Pyne, is for Australia to own and store the Design Intellectual Property of the new submarines. Negotiating how this Intellectual Property is captured by the Australian Government from the French Government owned shipbuilder DCNS, will be a key deliverable to focus upon, separate from the construction of the 12 new submarines. The Australian Government appears to be in the process of shutting down the ASC in 2017. The challenge for the Australian Government will be how it believes it can deal with the 95% risk of avoiding the "*Megaproject Paradox*" in SEA 1000 if it loses the "*Lessons Learned*" by shutting down the ASC.

6. **Organisation**: SEA 1000 will be tasked with coordinating the efforts of many hundreds of Australian companies and well in excess of 10,000 people in Australia in the Execution Phase along with numerous companies in France, the USA and other locations overseas. The number of people involved in the SEA 1000 supply chain will probably number in the tens of thousands globally across the SEA 1000 Life Cycle. Already in early 2017, DCNS is on record as frustrated at the lack of Australian companies identifying an interest in becoming involved in SEA 1000. Is this because they expected to become involved in SEA 1000 through the ASC supply chain? Is the Australian Government as "*Owner*" going to make it clear whether the ASC is not to be engaged in SEA 1000 so that the ASC Supply Chain can be recreated by DCNS? Confused communication is a source of "*Megaproject Paradox*" issues in early 2017 for SEA 1000.

7. **Geolocation**: SEA 1000 will leverage participating companies in a supply chain that will cover Australia, France, and the USA at the very least. Focusing that supply chain at the "*Owner's*" goal for Megaproject Execution will be a complex task and will require managing remote teams, in different time zones, with different languages and different cultures.

8. **Risk**: SEA 1000 as a Megaproject assumes at least a 95% failure rate risk and liability in terms of achieving the "*Owner's*" benchmark "*predictable simultaneous achievement of Project Cost and Project Schedule*" in the Execution Phase. The Australian Government as the "*Owner*" has the goal of sharing the risk and liability with all members of the supply chain. The "*Owner*" shares the risk with the non-owner supply chain by using appropriate contractual instruments to ensure accountability for deliverables achieved to meet the "*Owner's*" benchmark of success. In early 2017, it appear the Australian Government is changing the agency tasked with carrying out the "*Owner's*" strategy for construction of SEA 1000 by shutting down ASC.

1.3.1 AUSTRALIAN NAVAL MEGAPROJECT CONSTRUCTION

In the 1980's, with bipartisan support, the Australian Government decided that a policy of Strategic Defence Investment in the ASC should commence. The first Naval Megaproject was to build Submarines at Osborne on the Port River in SA. The strategy was intended to develop an Australian Defence Manufacturing Capability capable of sustainably supporting RAN in times of conflict. Prior to this time, Australia myopically purchased second hand or even new Naval Ships from overseas (eg the Oberon Class Submarines from the UK).

The only blueprint for building Submarines in Australia in 2017 exists at the ASC. It is one of relatively few places around the world that can say it has any blueprint at all for building, supporting and maintaining the operation of modern submarines.

ASC's Blueprint for Submarine Construction, Operation and Maintenance was developed in conjunction with the Swedish company Kockums. ASC built 6 Collins Class Submarines currently used by the Royal Australian Navy (RAN) in conjunction with Kockums. DCNS, the French Government owned Shipbuilder also has a blueprint for building Submarines. The Barracuda class (or *Suffren* class) is a new nuclear attack submarine designed by DCNS for the French Navy, replacing the Rubis-class submarines. Construction of the Barracuda Class for the French Navy began in 2007 and the first unit will be commissioned in 2018. The French design will be used and modified appropriately by ASC to build 12 Conventional Submarines for RAN's requirements. The 12 New Australian Submarines will replace the 6 Collins Class Submarines that are due to come to the end of their operational life in the next 20 years as the new submarines are commissioned.

There is also a strong blueprint that exists both at ASC Osborne and at ASC Henderson in WA for Operations and Maintenance of Submarines for RAN. The two Australian blueprints (i) For Construction of Submarines and (ii) For Operations and Maintenance of Submarines, has been built up over a 30-year period. Commencing in 1986 with the construction of the ASC Osborne site, the Australian Government and RAN have been cultivating a level of Australian Defence Capability in conjunction with Australian Industry that contributed to the decision made by Prime Minister Turnbull in April 2016 for the Construction of the SEA 1000 Megaproject.

ASC is the Australian company that has deliberately been planned, grown and cultivated since the 1980's to build Submarine Megaprojects in conjunction with judiciously selected global partners. In the Procurement and Execution phase of a Submarine Megaproject, ASC is tasked with sourcing as much input as possible from Australian Industry to build the Submarines and to build local Australian Defence Industry Capability in the process.

The following historical analysis provides some insight into ASC's history of Designing, Engineering, Procuring, Fabricating, Constructing, Commissioning, Operating and Maintaining Submarines and Surface ships for the RAN. This history is a superficial review, but provides an appropriate level of insight into the Preparation Phase of a Megaproject like the Collins Class Submarine Megaproject or the New AUS$50 Billion SEA 1000 Megaproject.

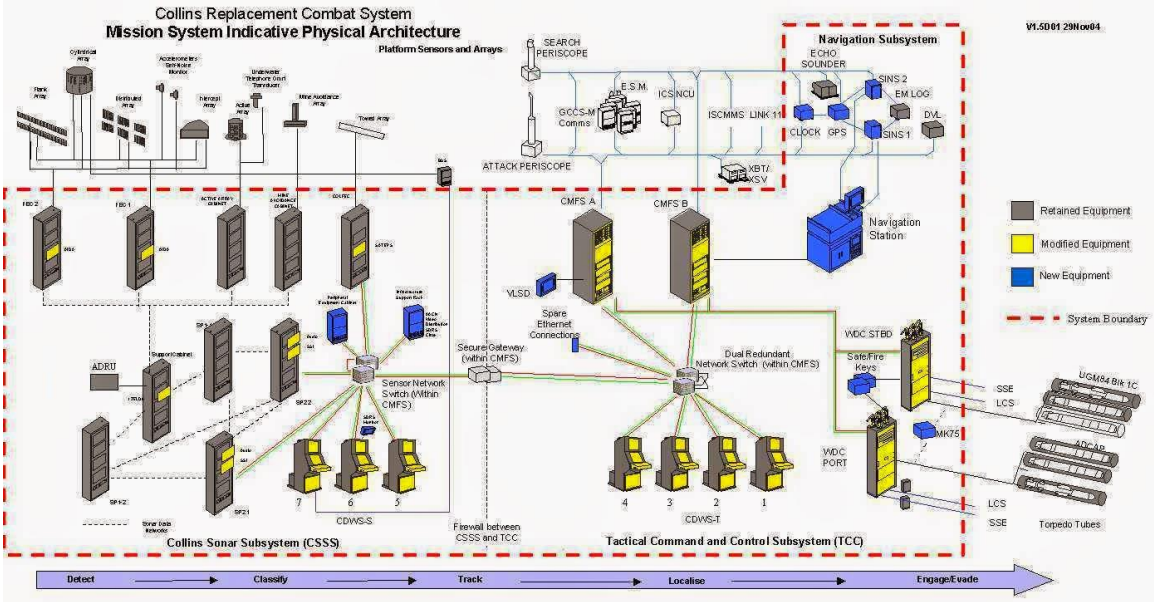
1.3.2 SUBMARINE CONSTRUCTION

In the 1980's the Collins Class Submarine Project was Australia's first serious attempt at the Execution of a multi-Billion Dollar Naval Megaproject. As of the launch of the first submarine, the project cost had increased from $3.892Billion in 1986 dollars to $4.989Billion in 1993 dollars. The increase of $1.1Billion corresponded to the rate of inflation during the same period. By 2006, $5.071Billion had been spent to build the 6 Collins Class submarines (excluding the fast track program).

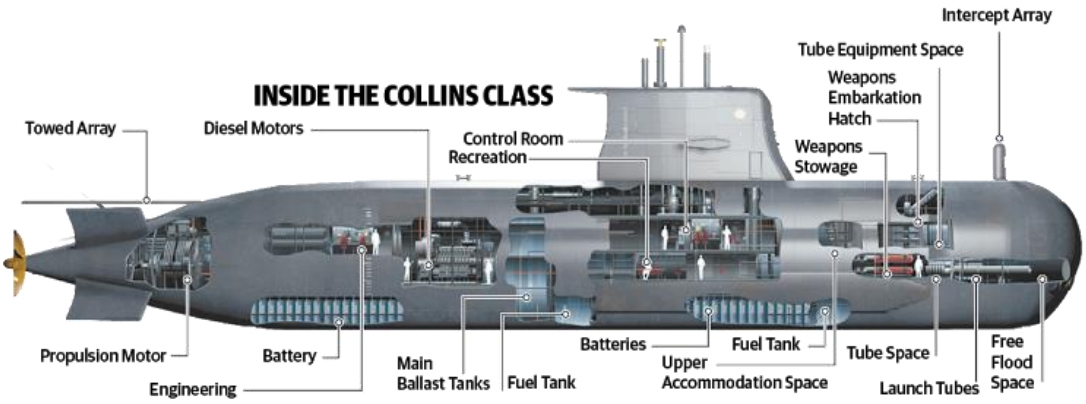
After taking inflation into account, the Collins Megaproject had run less than $40Million over contract. By any measure, and certainly by the measure introduced in this article from the CII, the ASC performed the Execution Phase of the Collins Class Submarine Project extremely well.

Consistent with Australia's 1980's Defence Procurement Strategy, decades have been spent constructing and installing large scale conventional submarine construction infrastructure at Osborne on the Port River in SA commencing 1986. Many companies from across Australia (and the world) have benefited from participation in the ASC Submarine Manufacturing process, but the focal point where it all came together was at Osborne in South Australia. Western Australia also significantly benefited because of the facilities that have been cultivated at Henderson in WA for the ongoing Operations and Maintenance of the Collins Class Submarines.

Companies from across Australia and the world have also been involved in the development installation and support of sophisticated and unique Combat Systems, Integrated Logistics Support Systems, Ship Control and Management Systems, Weapons Systems and other IT Systems that have been deployed on the Collins Class Submarines.

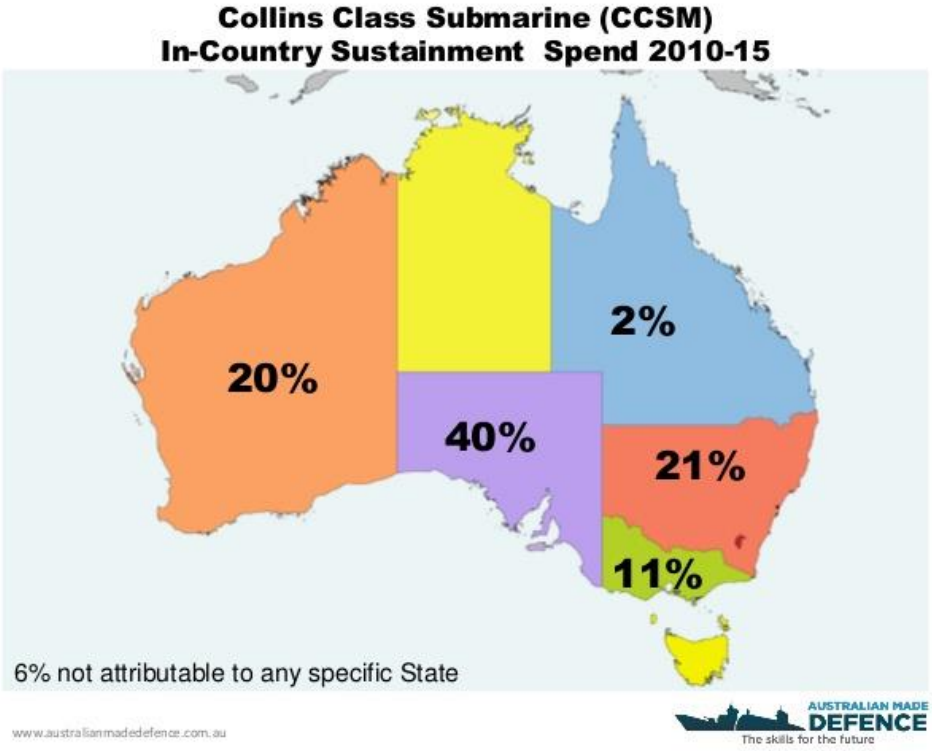


The 6 Collins Class Submarines were built between 1990 and 2003. The Collins Class Design was based upon the Swedish shipbuilder Kockums submitted Type 471 design, an enlarged version of the Västergötland class submarine operated by the Swedish Navy.



Each submarine was constructed in six sections, each section consisting of several sub-sections. One of the main criteria of the Collins Megaproject was that Australian industries contribute to at least 60% of the work. By the conclusion of the Collins Megaproject, 70% of construction and 45% of software preparation had been completed by Australian-owned companies. ASC has developed and fostered an excellent Supply Chain based around Australian Industry Participation in the Construction and ongoing Operations and Maintenance of the Collins Class Submarines. Across the duration of the Collins Megaproject, work was sub-contracted out to 426 companies across 12 countries, plus numerous sub-sub-contractors. In many cases, components for the first submarine were constructed by companies outside Australia, while those for the following five boats were replicated by an Australian-owned partner or subsidiary.

The Collins Megaproject prompted major increases in quality control standards across Australian Industries. In 1980 only 35 Australian companies possessed the appropriate quality control certifications for Defence projects. By 1998 this number had increased to over 1,500 Australian companies.



Although the acquisition project organisers originally planned for the first submarine to be constructed overseas, the Australian Government Cabinet decided as part of the project's approval that all 6 submarines would be built in Australia. The increases in construction time

and cost from not building the lead ship in the winning designer's home shipyard was considered to be offset by the additional experience provided to Australian industries. Even so, 2 sections of the first submarine were constructed by Kockums' shipyard in Malmo Sweden.

By the end of 1990, Chicago Bridge & Iron (CBI) and Wormald International had both sold their shares in ASC. The shares were acquired by Kockums and the Australian Industry Development Corporation (AIDC), with some of Kockums' shares then sold to James Hardie Industries to maintain Australian majority ownership of the company. On 5 April 2000, the shares in ASC held by Kockums were bought out and the company was nationalised despite a trend at the time to privatise government-owned companies. At the end of 2003, a contract to maintain the Collins class worth $3.5 billion over 25 years was awarded to ASC.

The Australian Government has always maintained a strategic ownership stake in ASC quite deliberately and consistent with its original strategy established in the 1980's. This strategy was of course informed from the prior 150 years' experience of the Australian Department of Defence having to defend Australia's borders and fight for the sovereignty of the country on the high seas.

The 6 Collins Class Submarines built at ASC on the Port River at Osborne, are and have been successfully maintained around Australia and the world by ASC in support of RAN's Operations. The Collins Class Subs are recognised as some of, if not the best Conventional Diesel Submarines in the world. For example, consider the video of Rankine in action in a successful Naval exercise against the US Navy off Hawaii.

https://www.youtube.com/watch?v=nqFVOL7mLd4

Rumour also has it that a Collins did the impossible and penetrated the US Carrier Fleet Defences to take a photograph of the Carrier's propellers in another similar exercise.

Name[63]	Pennant[63]	Laid down[64]	Launched[64]	Delivered[55]	Commissioned[63]	Namesake[65]
Collins	SSG 73	14 February 1990	28 August 1993	15 July 1996 (18 months late)	27 July 1996	Vice Admiral Sir John Collins KBE, CB
Farncomb	SSG 74	1 March 1991	15 December 1995	15 December 1997 (22 months late)	31 January 1998	Rear Admiral Harold Farncomb CB, DSO, MVO
Waller	SSG 75	19 March 1992	14 March 1997	30 April 1999 (27 months late)	10 July 1999	Captain Hector Waller DSO and Bar
Dechaineux	SSG 76	4 March 1993	12 March 1998	21 July 2000 (31 months late)	23 February 2001	Captain Emile Dechaineux DSC
Sheean	SSG 77	17 February 1994	1 May 1999	25 August 2000 (21 months late)	23 February 2001	Ordinary Seaman Edward Sheean
Rankin	SSG 78	12 May 1995	26 November 2001	18 March 2003 (41 months late)	29 March 2003	Lieutenant Commander Robert Rankin

1.3.3 SURFACE SHIP CONSTRUCTION

Subsequent to the successful completion of the construction of the Collins Class Submarines, the requirement for modern warships was established by the Kinnaird Review in 2003 and a new Air Warfare Destroyer Megaproject defined. Gibbs & Cox and Navantia submitted warship designs to the Commonwealth Government. The Australian Government selected ASC as the shipbuilder for the AWD Megaproject in May 2005. In June 2007, Navantia's existing design was selected as a platform for the AWD program.

https://www.youtube.com/watch?v=kwUvIDyQACE

Three ships were ordered in October 2007, all to be assembled at ASC's facility in Osborne SA from 31 pre-fabricated modules (or 'blocks'). The AUS$8 billion, three-ship deal included the option to order a fourth ship at a later date. The option to build a fourth destroyer was included in the original contract, but has not been exercised. ASC, NQEA Australia and the Forgacs Group were selected in May 2009 to build the blocks, but within two months, NQEA was replaced by BAE Systems Australia.

https://www.youtube.com/watch?v=n4JR8Ai_bBk

Unlike the Collins Class Submarine Construction, Project Schedule has grown significantly for the AWD Megaproject. Construction errors and growing delays led the AWD Alliance to redistribute the construction workload in 2011, with some modules to be built by Navantia. Increasing slippage has pushed the original planned 2014-2016 commissioning dates out by at least three years, with lead ship Hobart to be completed by June 2017, Brisbane in September 2018, and Sydney by March 2020.

ASC entered into an Alliance-based contract with the Defence Materiel Organisation and Raytheon Australia. The project passed critical design review in January 2010. The AWD platform is based on the Navantia-designed F100 Frigate, which is in service with the Spanish Navy. The baseline design has been slightly modified for Australian use, including the displacement of the AWD being increased to 7,000t, and the hangar modified to accommodate a range of helicopters.

https://www.youtube.com/watch?v=trZZQx7fepw

This strategic decision involved multiple Shipyards around Australia, and for the AWD Megaproject a Spanish partner was used as opposed to a Swedish partner for the Collins Megaproject. The Hobart Class AWD's are the result. The ASC facility was significantly expanded and upgraded to enable the fabrication of Surface Ships as well as Submarines.

The AWD Megaproject is coming to a close and so ASC has for some time been winding construction operations down as successive Australian Labour and Liberal Governments failed to make any concrete decisions with regard to New Submarine or Surface Ship projects.

https://www.youtube.com/watch?v=N4lDG64rcyQ

1.4 THE POLITICS OF MEGAPROJECTS

During the Preparation Phase of work for the SEA 1000 Megaproject, Australian Political machinations seemingly ignored the prior 30 years of development of Defence Industry Capability in Australia. The Labour Government decided to build 12 New Submarines in the SEA 1000 Project in Australia as announced in May 2009. Political arguments subsequently ebbed and flowed on both sides of the Australian Political divide (Labour and Liberal). From 2009 until it lost the 2013 election, the Labour Government prevaricated and eventually did nothing concrete in terms of making a decision to proceed with SEA 1000. Prior to the 2013 election, the Liberal Government (then in opposition) promised to honour the commitment to build 12 New Submarines in Australia. Once elected, the story from the Liberal Government changed, and kept changing.

On the extreme side of politics, economic rationalist arguments for the cheapest price build anywhere in the world totally ignored the requirement for a country to have control over its own Defence Capability in times of conflict. Political promises that were made prior to the 2013 Federal election to build the New Submarines in Australia consistent with Australian Procurement Policy were reneged upon. The lack of support for both historic and future Australian Industry Participation in local construction of the SEA 1000 Megaproject was palpable from the Australian Liberal Government. No more so than when the sitting Defence Minister suggested he had no confidence in the ASC to build a canoe, let alone a Submarine.

These outrageous statements lead to the immediate resignation of the Defence Minister. A "Captain's Pick" was subsequently made by a Prime Minister to build Australia's new Submarines in Japan. These successive political statements and decisions were considered significant contributors to the political demise of an Australian Prime Minister and his second replacement Defence Minister at the hands of their own party.

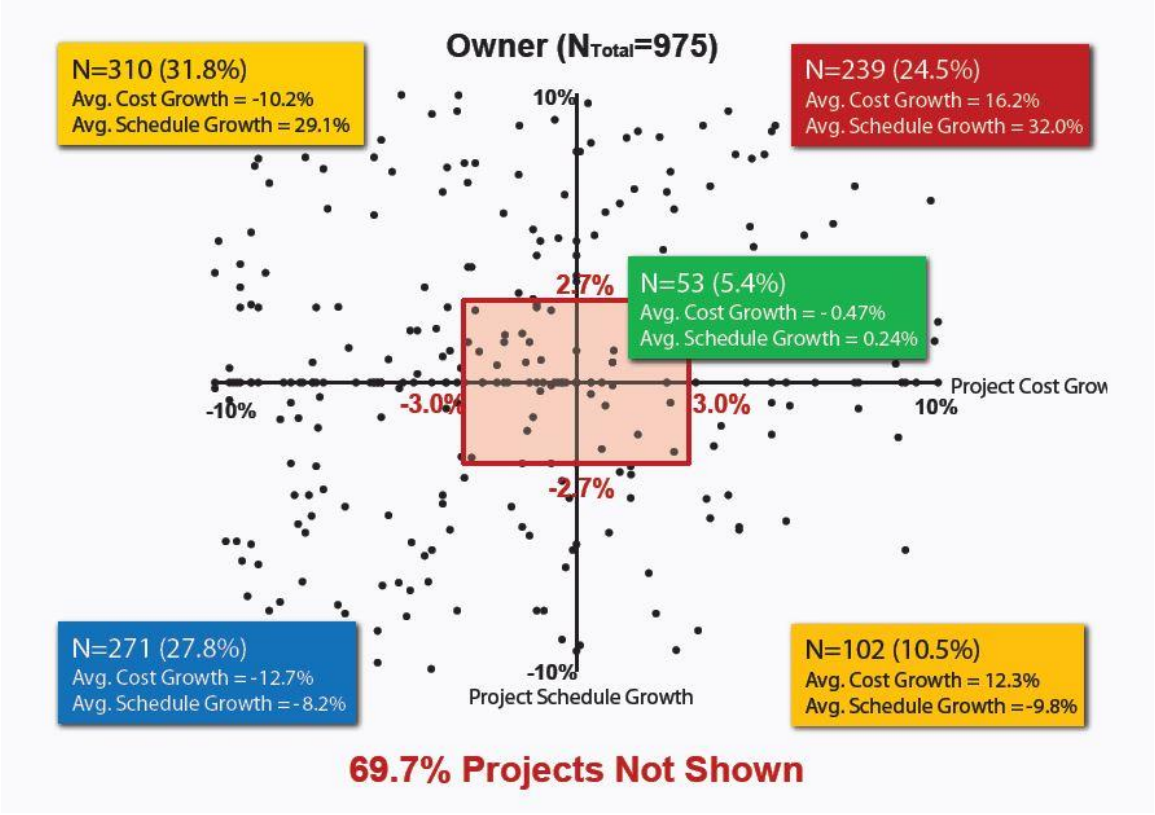
In April 2016, a decision on SEA 1000 was made, 30 years since the first Decision by the Australian Government to invest in local Australian Defence Manufacturing Capability. The decision specifically supported Submarine and Surface Ship Construction and Operations and Maintenance in Australia. The decision announced by Prime Minister Turnbull reinforces the Australian Defence Procurement strategy developed over the past 30 years. Turnbull recognised the only blueprint for Submarine Construction that exists in Australia, lives at Osborne on the Port River in SA. It is a Blueprint that has come from over 30 years of procurement experience investing AUS$5 Billion building and AUS$3.5 Billion Operating and Maintaining the Collins Class Submarines and AUS$8 Billion building the Hobart Class Air Warfare Destroyers.

There has been much criticism of the ASC and its Collins Class Submarine and Hobart Class AWD Megaprojects over the years. Much of this criticism has come from journalists, economic rationalists or political commentators with little or no understanding of the level of complexity involved in the Megaprojects about which they report or comment on. This article and follow on Parts to the "*Megaproject Paradox*", will compare ASC Megaprojects to an analysis of 975 Megaprojects from around the world. Only through the lens of 20/20 hindsight comparison with other global Megaprojects can the quality and value for money of ASC's work be seriously and professionally reviewed.

Without doubt, ASC in partnership with the Australian Government has developed a 30-year history of building, operating and maintaining Submarine and Surface Ship Megaprojects. The Australian Government has invested in the order of AUS$17 Billion in the ASC over that 30-year period. The investment in time, money, intellectual property at the ASC, and growing Australian Defence Industry Capability associated with these first two Megaprojects is extremely sophisticated and invaluable to Australia's growth as a nation.

It was hoped that the ASC was recognised by Prime Minister Turnbull as the crystallisation of Australia's 30-year investment in the Preparation Phase for the 12 New Australian Submarines in the SEA 1000 Megaproject commencing in April 2016. However, as of early 2017 it appears the Australian Government is still playing politics with the future of ASC. Whether ASC has anything to do with the fabrication of SEA1000 remains to be seen. As time passes, it looks like the Australian Government is doing everything it can to dismantle ASC.

1.5 MEASURING MEGAPROJECT PERFORMANCE



One way to measure Megaproject Performance is using 20/20 hindsight. Reviewing actual Project Cost and Project Schedule in the Execution Phase of a Megaproject against that predicted at the end of the Preparation Phase for the Megaproject is used here as a learning tool. CII produced a 2012 Megaproject Performance Assessment Report that studied the performance of 975 Megaprojects from the "*Owner's*" perspective. CII plotted the location of each Megaproject on a graph of Project Cost Growth vs Project Schedule

Growth as shown above. The "*Pink Box*" around the origin of the graph identifies the region in which the 975 CII "*Owners*" considered a successful Megaproject should fall once the Execution Phase is completed.

As a growing number of Megaprojects are being implemented around the world, it is becoming obvious that they typically perform very poorly in the eyes of the "*Owners*". On the graph, only 5.4% or 53 of the 975 Megaprojects studied were considered by the "*Owners*" to be "*predictable simultaneous achievement of Project Cost and Project Schedule*" in the Execution Phase, as shown in the "*Pink Zone*". As the graph shows, Megaprojects often experience substantial simultaneous Project Cost and Project Schedule overruns (24.5% or 239 of the 975 Megaprojects studied). But it is not uncommon to hear of "*Cost Driven Projects*" (31.8% or 310 of the 975 Megaprojects studied) or "*Schedule Driven Projects*" (10.5% or 102 of the 975 Megaprojects studied) as shown on the graph in the two "*Yellow Regions*". These labels are euphemisms for "*Owners*" who have lost control of their Megaproject. The teams running these projects do not understand that it is "*predictable simultaneous achievement of Project Cost and Project Schedule*" in the Execution Phase that is required to meet the "*Owner's*" benchmark for success.

A significant number of Megaprojects come in well below the estimated Project Cost and well ahead of the estimated Project Schedule (27.8% or 271 of the 975 Megaprojects studied) shown in the "*Blue Region*". It is counter intuitive, but these projects are also considered by "*Owners*" to be out of control. How can that be if Megaprojects cost less and are completed faster than the owners expected? The procurement teams that performed the task of estimation in the Preparatory Phases prior to commencing the Megaproject are considered to have underperformed. The procurement team's under performance in the Preparatory Phases meant that "*Owners*" committed greater funds and greater time to those Megaprojects than were necessary. The resultant over commitment of funds and time is at the expense of other Megaprojects in the "*Owner's*" portfolio. If the Megaproject estimates were performed accurately in the Preparatory Phases, other "*Owner*" Megaprojects could have proceeded at the same time, or benefited from additional investment.

Megaprojects are getting bigger and more complex, and increasingly they are falling significantly outside Project Cost and Project Schedule parameters predicted by traditional deterministic project management practices. Similarly, as Megaproject "*Organisations*" become larger and operate beyond traditional boundaries it becomes increasingly difficult to pinpoint obstructions to high productivity, let alone more effective ways of operating.

Associations or Companies such as CII and IPA spend a great deal of time collecting data on the history of the execution of projects of all scales. This data is typically static data collected through surveys and interviews and form useful historical snapshots of a given point in time of a Megaproject. The graph from CII above considers only the actual simultaneous Project Cost and Project Schedule for the Execution Phase of work compared with the estimate given at the conclusion of the Megaproject Preparatory Phases, FID. The study of 975 completed Megaprojects from around the world enables 20/20 hindsight to provide a useful foundation for future Megaprojects in the Preparation Phase. "*The Noonan Method for Megaproject Risk Mitigation*" can make great use of this historical data to form the initial boundary conditions for its "*Organisation*" Design and Model process.

1.5.1 LEARNING FROM 20/20 HINDSIGHT

CII has identified that it is at the capital budgeting stage of a project where the erosion of project benefits begins. As highlighted with the Australian SEA 1000 Megaproject, the Preparation Phase of a Megaproject costs in the order of a billion dollars or more and lasts for a decade or more. The investment in funds and time in the Preparatory Phases of a Megaproject by the "*Owner*" underscores how important accurate predictable estimates for simultaneous achievement of Megaproject Cost and Megaproject Schedule are to the "*Owner*".

The "*Owner*" estimated financial returns from a capital project typically turn out to be optimistic. This may occur because of a poor understanding of a product's market, optimistic or pessimistic estimates of the cost and schedule of the Megaproject itself, or all of these. CII research has conclusively shown that full funding authorisation should not be awarded when a project has poor scope definition or inadequate business planning as this almost guarantees poor Megaproject performance. It has not been well understood by Megaproject "*Owners*" that the predictability of simultaneous Project Cost and Project Schedule performance is crucial for the attainment of financial performance stemming from a company's portfolio of projects.

The notion of a "*Cost Driven Project*", or a "*Schedule Driven Project*" is widely accepted in the market. Much of the capital projects industry has improperly decided that it is acceptable to pay more for schedule or to take excess time in the interest of saving money. The problem isn't so much that Project Managers are optimizing cost or schedule, but rather in doing so, they are seriously compromising the "*Owner's*" financial performance.

As of 2012, CII's review of 975 "*Owners*" submitted projects revealed that only 5.4% of Megaprojects met both their authorized predicted simultaneous Project Cost and Project Schedule within an acceptable margin (i.e. projects exhibiting first quartile delta Project Cost Growth and first quartile delta Project Schedule Growth shown in the "*Pink Zone*"). Worse, nearly 70% of the submitted projects had actual Project Costs or Project Schedules exceeding +/- 10% deviation from their authorised values. These 70% of projects are therefore not even shown on the graph included with this article.

In the graph five regions are shown. Four of the regions are divided by positive or negative Project Cost and Project Schedule Growth relative to 0% respectively. The region containing Projects with both first quartile delta Project Cost Growth and delta Project Schedule Growth is shown in "*Pink*" (i.e. projects with '*best in class*' predictability). This is the bulls eye, or the target that all Megaprojects should be focused at. Each region is listed with its corresponding percentage of the 975 owner-submitted projects and its average Project Cost and Project Schedule Growth. For reference, the "*Red Region*" contains projects whose actual costs and schedules exceeded their budgeted values. This article proposes that the successful 5.4% of projects that fell in the "*Pink*" probably did so based on sheer luck or fluke.

More than anything, an "*Owner's*" Executive Leadership Team (ELT) needs predictable Megaproject performance. This does not imply that Megaprojects have to be overtly cost effective relative to Megaprojects executed by other "*Owners*", that benchmark is of

secondary importance. The main requirement is that Megaprojects must be simultaneously predictable in both Project Cost Growth and Project Schedule Growth to achieve the "*Owner's*" benchmark of success. Without predictability, things start to go wrong, and losses start accruing for "*Owners*".

1.6 20/20 HINDSIGHT ANALYSIS OF COLLINS VS AWD

The Collins Megaproject performed extremely well on Project Cost Growth, exceeding its estimated "*Cost*" by only $40 Million when taking into account inflation. This is an actual Project Cost Growth of less than 0.1% when taking inflation into account.

However, for the purposes of remaining consistent with the CII evaluation introduced in this article, the final Project Cost of the Collins Class Submarine Megaproject was AUS$5.071 Billion at completion as measured in 2006 against an estimated Project Cost of AUS$3.892 Billion in 1986, FID. This represents an actual Project Cost Growth of +30.3% for the Collins Megaproject. The last of the Collins Class Submarines was delivered 41 months late on a project that commenced in 1986 and expected delivery of the final Submarine in 2000. This represented a Project Schedule Growth of +24.4%. On the CII graph shown above, the Collins Megaproject would fall in the "*Red Region*", with 24.5% or 239 out of 975 other Megaprojects.

The AWD Megaproject commenced in 2007 and was expected to "*Cost*" AUS$8 Billion with a completion date for the third AWD expected in 2016 at FID. With 20/20 hindsight, the original method used to estimate AWD Project Schedule by the "*Owner*" has been called into question. It is believed that the "*Owner*" used a method that took the Schedule from one of the later hulls of a US Defence Naval Shipbuild that produced 7 or more hulls. The reality in Naval Ship builds is that the first in class hull will always take longer than subsequent hulls, which is the same experience with the AWD construction. The AWD Megaproject is yet to be completed but is already significantly over "*Cost*" and significantly over Schedule estimated at time of FID. The AWD Megaproject will also fall in the "*Red Region*" with 24.5% or 239 out of 975 other global Megaprojects. Dramatic publicity in 2016 would have people believe that the AWD Megaproject is performing terribly. People may infer that AWD is expected to have significantly worse results than the Collins Megaproject. The reality as predicted in 2016 is identified in an analysis using public domain information below.

Expectation in May 2016 is that the AWD will "*Cost*" in the order of AUS$1.2 Billion more than expected, which represents a Project Cost Growth of +15%. When compared to the Collins Megaproject, the AWD result is actually superior to the Collins Project Cost Growth of +30.3%. Collins Project Schedule Growth came in at +24.4%. If the AWD Megaproject is completed in 2020 as expected in 2016, the actual Project Schedule Growth for the AWD Project will be in the order of +44.4%. AWD Project Schedule Growth is significantly greater than the Collins Megaproject Schedule Growth. AWD Megaproject Schedule Growth however is a deliberate result of the "*Owner*" moving into "*Cost Driven Project*" mode to minimise Project Cost Growth at the expense of Project Schedule Growth.

https://www.youtube.com/watch?v=14bg1naZrGU

This begs the question, "*what was different about how the AWD Megaproject was executed compared to the Collins Megaproject*"? As with the answer to any such question of comparison between Megaprojects, the answer is complicated. To begin to answer the question, each of the "*Noonan Megaproject Descriptive Parameters*" defining a Megaproject must be examined. Using the "*Descriptive Parameters*" given at the commencement of this article a comparison can be made and indications of the difference between the two Megaprojects gauged, as "*Lessons Learned*" for the SEA 1000 Project.

https://www.youtube.com/watch?v=UzEP4KP9ARY

1.7 THE NOONAN METHOD APPLIED TO ASC

The following analysis uses the "*Noonan Megaproject Horizontal Parameters*" or "*Descriptive Parameters*" to provide a comparative 20/20 Hindsight analysis of the Execution Phase of the two Megaprojects completed by the ASC Pty Ltd for the Australian Government. The benefit of this analysis is to identify "*Lessons Learned*" using 20/20 hindsight. The "*Lessons Learned*" should then be used in a 20/20 Foresight analysis of the SEA 1000 Project to deploy the most appropriate Megaproject Organisation to Execute the SEA 1000 Megaproject successfully. The two Megaprojects used in the 20/20 Hindsight analysis are (i) The Collins Megaproject, for the construction of 6 Conventional Diesel Submarines and (ii) The AWD Megaproject, for the construction of 3 Air Warfare Destroyer Surface Ships.

1.7.1 COLLINS V AWD OWNERSHIP

ASC Pty Ltd, formerly the Australian Submarine Corporation, is an Australian Government Business Enterprise involved with Australian naval shipbuilding, headquartered at Osborne in Adelaide South Australia. Kockums, Chicago Bridge & Iron, Wormald International and the Australian Industry Development Corporation (AIDC) joined forces to create the Australian Submarine Corporation in August 1985 to tender and once successful, design and build the new fleet of Collins submarines for the RAN. The ASC construction facility was established on previously undeveloped land on the bank of the Port River at Osborne, South Australia. Work on the site began on 29 June 1987, and it was opened in November 1989. By the end of 1990, Chicago Bridge & Iron and Wormald International had both sold their shares in ASC. The shares were bought up by Kockums and the AIDC, with some of Kockums' shares sold to James Hardie Industries to maintain an Australian majority ownership of ASC. On 5th April 2000, the shares in ASC held by Kockums were bought out and the company was nationalised despite a trend by the Government towards privatisation of government-owned companies at that time. The company's name was changed from the Australian Submarine Corporation Pty Limited to ASC Pty Ltd on 1 October 2004 in order to position it as a supplier of naval combat vessels in addition to being a specialist submarine supplier and maintainer. The name ASC was specifically selected to recognise the company's heritage and achievements.

When awarding the AWD Project, the decision at the time was not to use the same strategy for ownership as was used in the Collins Megaproject. In 2004, the Australian Department of Defence identified that the future Air Warfare Destroyer class would be built around the United State Navy's Aegis Combat System. The use of Aegis was formally

approved in April 2005, and Raytheon Australia was brought into the AWD project with the responsibility of integrating the Aegis system into the selected design, along with modifications to accommodate RAN preferred electronic warfare equipment, underwater sensors, and weapons. In May 2005, the ASC shipyard in SA, was identified as the primary shipbuilder for the project. In late 2005, the AWD Alliance was formed to organise and implement the project. The Alliance is a consortium including the Defence Materiel Organisation (DMO), ASC's project dedicated subsidiary, and Raytheon.

After receiving tenders from Blohm + Voss, Navantina and Gibbs & Cox among others, the Australian government identified Gibbs & Cox's Evolved Flight II Arleigh Burke - class destroyer as the preferred design in August 2005. The Alvaro de Bazan-class frigate designed by Navantina was identified as the official alternative, and both designs began further testing and modification as part of a two-year selection process. Despite the American destroyer being the preferred option, the conclusion of the selection process in late June 2007 saw Navantia's design selected. The Spanish ships were considered a less-risky design as, unlike the Evolved Arleigh Burkes, which at that point only existed as an on-paper design, vessels of the Spanish design had been built and were operational. The Álvaro de Bazán derivatives were predicted to be in service four years earlier than the American-designed ships, and would cost AUS$1 billion less to build. There were further financial and technical benefits in ordering the AWDs and the Canberra - class Landing Helicopter Dock (LHD) ships from the same supplier.

Originally, the Hobart-class destroyers were to be operational between December 2014 and June 2017. In September 2012, the ongoing delays prompted revision of the entry-to-service dates to March 2016, September 2017, and March 2019. In May 2015, the DMO announced additional schedule slippage, with *Hobart* to be handed over to the RAN in June 2017, *Brisbane* due in September 2018, and *Sydney* by March 2020. The original contract cost was A$8Billion for the three ships. By March 2014, the project was running A$302Million over budget. By May 2015, this had increased to A$800Million, with a predicted minimum cost overrun by project end of A$1.2Billion.

The ownership role of the AWD Megaproject was compounded by establishing both the ASC and the DMO as partners in the AWD Alliance along with Raytheon. 20/20 Hindsight indicates that this was an unfortunate set of circumstances as the contract between "*Owners*" was compounded with the relationship contract for construction and Execution of the Megaproject. Perhaps if DMO had taken on the role of "*Owner*", with ASC alone in partnership with Raytheon in an Alliance the contract may have established a hierarchy of control that could have worked more successfully?

1.7.2 COLLINS VS AWD LIFE CYCLE

The "*Life Cycle*" governing both Collins and AWD Megaprojects uses a strategy dictated by the Australian Department of Defence Procurement policies. Comparison of the approach governing a mid 1980's Megaproject as compared to a mid 2000's Megaproject must be made to identify any detailed differences. A superficial analysis will be attempted here. This analysis in no way should be considered an appropriately detailed analysis that could come from performing a full due diligence exercise.

The Government in power in Australia at the time of the decision for both Collins and AWD Megaprojects was a Labour Government. But an analysis of policy differences impacting Defence Procurement must be made between decisions taken in the mid 1980's as opposed to the mid 2000's.

Some critical Australian Government Policy and Trade differences contributed significantly to the different ways Collins and AWD projects were executed. One analysis follows:

- **Political Climate:** The people involved in the decision-making process at both Political and Administrative levels for Collins and AWD had almost entirely changed because of the 20-year time lapse between decisions. The gradual change in Australian Government policies introduced by both sides of the political divide in Australia by the mid 2000's made Australia a much less regulated and financially constrained country than it was in the mid 1980's. Australian Engineering standards have become significantly undermined by economic rationalists in government and industry alike leading to trade deregulation. The political, economic and trade scenarios in the mid 2000's were manifestly different to the mid 1980's. It was straight forward and easy for companies to import goods and products into Australia that did not comply with the very Engineering Standards that construction and manufacturing companies working within Australia were forced by regulation to comply with. This had direct detrimental impact on AWD Megaproject Execution in ways that did not happen with the Collins Megaproject Execution.

- **Australian Professional Engineering Bodies:** In the mid 1980's the Association of Professional Engineers Australia (APEA) was the Engineers Union affiliated with the ACTU. The APEA was tasked with maintaining employment terms and conditions of Engineers in Australia. The APEA was very active in promoting and maintaining standards of work associated with the Engineering Profession in Australia, along with the Institution of Engineers Australia, including protecting Australian Standards applied to Manufacturing and Construction. The APEA started life in 1946. In 1991, the APEA charter changed when it became APESA, the Association of Professional Engineers and Scientists Australia. In 1994 the charter further changed when it became APESMA, the Association of Professional Engineers, Scientists and Managers Australia. In 2013, the latest charter change occurred when the organisation became Professionals Australia. This one organisation is tasked with representing employment terms and conditions for a wide and diverse group of professionals and managers. The question must be asked whether this organisation remains capable of provision of appropriate focus needed for Engineers in Australia, and the support required for Australian Standards applied to Megaprojects.

- **Australian Engineering Standards:** Subsequent to the 1980's, the APEA, APESA, APESMA and now PA organisations have been critical of the change in staff profile within Commonwealth Government. Concerns have been expressed about significantly reduced numbers of Professional Engineers employed to review Government owned Megaprojects. The current Chief executive of Professionals Australia Chris Walton said in 2014 that a shortage of qualified personnel within

> Defence Materiel Organisation, one of the AWD Alliance partners, meant the Australian Government had become an uninformed purchaser. Mr Walton said the government needed more in-house engineers to detect and prevent potential problems. Mr Walton said he was concerned that not all of the Design Acceptance Representatives on the AWD project with responsibility for inspecting and approving work were government employees. He said proper oversight by government engineers might have prevented Chinese-made copper pipes being accepted and installed on the Hobart destroyer before later being ripped out due to faults. Other problems included watertight doors having to be rebuilt due to a failure to meet Australian design standards. Only about 95 of the 1900 people on the AWD Megaproject were government employees. Walton said "*It is difficult to imagine how five per cent of the workforce can effectively safeguard the Commonwealth's interests as the owner of such a complex project. These cost blowouts show how expensive it can be when governments fall short on investing in engineering capacity, but there are also increased risks, more waste, more delays and failures.*" Mr Walton described engineers "*as the last line of defence*" for taxpayers on major Defence construction projects.

In summary, the level of strict regulation and measurement of progress related to the application of Australian Standards to the Execution Phase of Collins was much more rigid than AWD. Trade deregulation caused by economic rationalism may have its uses for less complex projects with short term goals. Arguably, economic rationalism has little or no role to play in relation to the Execution of Megaprojects, unless it is structured appropriately within the Preparatory Phases of the Megaproject to review competitive pricing from alternative supply chain solutions. Even then, if a lower price is chosen, checks and balances must be put in place to ensure quality is not being compromised to the point where overall success of Execution of the Megaproject, or worse, the long-term Operations and Maintenance Phase of the Megaproject is placed in jeopardy.

1.7.3 COLLINS V AWD COST

The "*Cost*" of the Collins project was estimated to be AUS$3.892 Billion when commenced in 1986 with completion of the 6 Collins class Submarines expected in 2000. The actual "*Cost*" of the Collins Megaproject was calculated at AUS$5.071 Billion in 2006 and was completed 41 months later than expected. The "*Cost*" of the AWD project was estimated to be AUS$8 Billion when commenced in 2007. The original expected commissioning Schedule for the three AWD's was from 2014-2016. This has slipped significantly and the AWD Alliance has been given the mandate to become a "*Cost Driven Project*" to limit Project Cost Growth as much as possible. The Commonwealth wants the AWD Alliance to commission the AWD's at a later time but as close as possible to the original "*Cost*". This has seen the projected commissioning schedule slip to 2017 - 2020. Considering the criticism coming from Chris Walton, CEO of Professionals Australia, perhaps a lack of appropriate number of Professional Engineers in the "*Owner*" "*Organisation*" is a significant contributing factor to the AWD Megaproject becoming a "*Cost Driven Project*"? Ironically, if AWD Project Cost Growth can be limited to the predicted AUS$1.2 Billion, the actual Project Cost growth of the AWD Project will be around +15%, which will be a significantly better result than that achieved by the Collins Megaproject at +30.3%.

1.7.4 COLLINS V AWD SCOPE COMPLEXITY

The "*Scope Complexity*" of the Collins project compared to the AWD project is arguably similar based upon a superficial "*Cost*", "*Life Cycle*" and "*Scope Complexity*" analysis. The "*Cost*" for Collins was predicted to be AUS$3.892 Billion in 1986 as opposed to the AWD cost predicted to be AUS$8 Billion in 2007. These "*Costs*" are arguably similar given the 20-year time difference in commencement of Execution. The expected delivery time frame for 3 x AWD's was within 9 years and has now slipped to a predicted 13 years by the time Execution has been completed. This is similar considering 6 x Collins class Submarines expected to be delivered within 14 years had slipped to 17 years by the time of completion of the Collins Execution Phase. As of early 2017, the natural speed up in delivery schedule that comes with the second and third hulls in a class of ships could see Hull 3 completed in 2018.

The Collins class is considered more complex in "*Scope Complexity*" than the AWD as the design was for submarines as opposed to surface ships. Submarines are considered by Engineers to be second in "*Scope Complexity*" only to the Space Shuttle. Navigating a Submarine is by definition more complex than a Surface Ship. The question must be asked, where else has "*Scope Complexity*" been increased for the AWD Megaproject.

The answer may lie in consideration of the form of "*Contract*" used for Execution, the Alliance "*Contract*". The Alliance "*Contract*" introduced additional complexities in that the Design "*Contract*" was separated from the Alliance Construction "*Contract*". By separating the Design "*Contract*" from the AWD Alliance "*Contract*", the Designer was relieved of accountability for Construction issues. This caused significant difficulties in dealing with the Spanish Designer that were not evident in dealing with the Swedish in relation to Collins. Example AWD difficulties caused by this separation of Design "*Contract*" from AWD Alliance Construction "*Contract*" are in two key areas. First, the Spanish Designer can modify the Design of the AWD at any time with no "*Contract*" accountability to the AWD Alliance Construction Contractor and how the design change impacts upon the construction phase of the AWD's. This level of "*Contract*" disconnect between Designer and AWD Alliance Construction contractor is a recipe of Delay and Cost overrun in construction.

By comparison, the Collins Megaproject captured Design and Construction within a single "*Contract*" vehicle, the ASC Pty Ltd. The Swedish partner was a major shareholder of the ASC. All Design Intellectual Property for the 6 Collins Class Submarines was captured under the ownership of the ASC Pty Ltd. Whereas with the AWD Alliance, none of the Design Intellectual Property is held by the AWD Alliance, that remains with the Spanish Contractor, Navantia.

It must also be noted that completion of the AWD Megaproject has been deliberately delayed by the "*Owner*" in an attempt to minimise Project Cost Growth. When considering the CII Megaproject Performance chart above, AWD has become a "*Cost Driven Project*". This may arguably reduce AWD "*Scope Complexityt*" compared to Collins and may minimise "*Contract*" Design difficulties between AWD Alliance and Navantia by allowing greater time to deal with the AWD Execution Phase.

1.7.5 COLLINS V AWD CONTRACT

A March 2014 report by the Australian National Audit Office (ANAO) heavily criticised the DMO and the AWD Alliance for underestimating the risks in redesigning the ships for Australian operations, and building them in shipyards with no recent warship construction experience.

The ANAO report also criticised designer Navantia and the shipyards involved in block construction over poor drawings, repeated errors, and bad building practices. As a result of further delays and growing costs, the Hobart-class destroyer project was added to the government's "*Projects of Concern*" list in June 2014. Follow-up government reports identified unrealistic time and "*Cost*" estimates as additional factors. The overarching Alliance concept has been repeatedly denounced, with no effective management structure or entity in charge. This allowed and probably fostered repeated blame-passing between the individual Alliance partners, Navantia, and subcontracted shipyards. The DMO was locked in a contradictory role, simultaneously acting as supplier, build partner, and customer.

Both the Collins and AWD Megaprojects fall in the red region of the CII graph. Surprisingly considering all the bad press for the AWD Megaproject, the results on Project Cost Growth and Project Schedule Growth speak for themselves. The AWD will be superior to the Collins Megaproject if its cost growth is kept within AUS$2.4 Billion growth over the original AUS$8 Billion target. However, the AWD Project Schedule Growth is definitely predicted to be worse at +44.4% compared to the Collins Project Schedule Growth of +24.4%. The question then needs to be asked, "*What has the Australian Government and the RAN lost from the AWD Project Schedule Growth*"? The answer appears to be that not a great deal has been lost by the AWD Project Schedule Growth, other than the "*Cost*" of employment of ASC personnel involved in the AWD Alliance for a longer period of time than originally contemplated.

With 20/20 hindsight of both Collins and AWD Megaprojects, the Alliance "*Contract*" method of managing a Defence Megaproject is probably the difference that is most under the spotlight. With two Australian Government Owned agencies as equal partners with a foreign privately held organisation in an Alliance, has the result produced a better or worse result than Collins? Was it a wise decision to separate the Design "*Contract*" from the AWD Alliance "*Contract*"? No final opinion is offered in this superficial analysis as there are too many questions that remain unanswered at this time. The AWD Megaproject remains to be completed before a fair comparison can be finalised sometime after 2018.

1.7.6 COLLINS V AWD ORGANISATION

The different ownership relationships used between the Collins Megaproject and the AWD Megaproject have had a distinct impact upon the structure of the organisations involved in the Execution of the two Megaprojects. Well in excess of 10,000 people have been involved in both Megaprojects across many hundreds of companies. However, the dramatic publicity given to the predicted "*Cost*" blowout on the AWD Megaproject gave rise to an Independent Assessment of the Air Warfare Destroyer (AWD) Program's "*Cost*", Schedule and quality performance.

The Independent review of the AWD Program was conducted by Professor Donald C Winter and Dr John White. The reviewers were tasked with the identification of remediation and mitigation actions to improve AWD Program performance. Recommendations for the transition of the AWD's into operational service with the RAN were also sought. In addition, the report sought to realise the national security benefits of the AWD Program and the long term benefits of the AWD Program for the Australian shipbuilding industry.

Investigations included briefings by the Commonwealth of Australia, AWD Alliance and industrial participants. Visits to AWD construction and engineering facilities in Australia, and conversations with individuals formerly associated with the program were also used. Reports from the ANAO and FMI were used as opposed to conducting independent reviews of productivity.

Two direct causes for AWD Megaproject Cost and Schedule Growth were identified:

1. The initial program plan for AWD development and production was unrealistic in its cost and schedule estimates.

2. The Alliance, as structured, composed and staffed, has been unable to effectively manage the AWD Program.

Contributing causes for AWD Megaproject Cost and Schedule Growth include:

1. Systems engineering on the AWD Program has been of limited effect.

2. The AWD Alliance and ASC were unable to effectively manage the AWD block subcontractors.

3. The oversight provided by the Commonwealth of Australia has been of limited effect.

The two systemic issues, which could affect any other naval shipbuilding program in Australia, were identified as:

1. The limited base of shipbuilding activity in Australia materially impacted the AWD Program.

2. The Commonwealth of Australia has not developed a long-term shipbuilding plan that can cost effectively support the needs of the RAN, while sustaining the Australian industrial shipbuilding base.

The potential options for addressing these issues were constrained by the inability to change the design, industrial participants, facilities and workforce of the AWD Program. The review found that time was of the essence and that more difficulties could be expected. There was a specific need to improve the program management function through the insertion of an experienced shipbuilding program management team. The review examined multiple options, from limited management change (as recommended by the ANAO), to program termination and development of a new acquisition strategy.

Considering the ASC had demonstrated an ability to manage the module construction for the Collins Class Megaproject, the question must be asked "*what if anything changed for the AWD Megaproject*"? The answer includes observations that (i) the key participants in the AWD Megaproject were different, including Raytheon, DMO, and Navantina, and (ii) the "*Owner*" and Non-owner supply chain were organised much differently under an Alliance "*Contract*" for AWD. However, Australian Government Policy and Trade conditions in the mid 2000's at commencement of Execution of AWD were significantly different compared to the mid 1980's at commencement of Execution of Collins. These differences cannot be ignored.

1.7.7 COLLINS V AWD GEOLOCATION

The major difference between the Collins and AWD Megaprojects was the key International partners involved and the timing of commencement of Execution. Both projects were globally engineered and fabricated and brought together at ASC Osborne. Collins worked with a Swedish Shipbuilding partner whereas AWD worked with a Spanish Shipbuilding partner. US partners were involved in both Megaprojects for the integration of the US designed Combat System. Any difference in performance between the two Megaprojects needs to carefully examine the performance difference between the key foreign partners in the Execution Phase of the Megaproject. The contractual instrument used to manage the Collins vs the AWD projects also needs to be considered for "*Lessons Learned*". A fair and accurate analysis between the two Megaprojects can only be conducted once the AWD Program has been finally completed sometime after 2018.

1.7.8 COLLINS V AWD RISK

"*Risk*" can be measured in many different ways. The proposal in the various parts to the Megaproject Paradox articles is to consider the fundamental risk to the Execution of a Megaproject as having at best a 5% chance of success or a 95% chance of failure based upon the 20/20 Hindsight CII study of 975 global Megaprojects. Understanding the probabilities of success/failure, using a 20/20 hindsight analysis for the next Naval Megaproject Executed in Australia (SEA 1000) empowers the owner to prepare itself in the best possible way to overcome the significant chance of failure.

In latter Parts of the Megaproject Paradox, new structured methods introducing 20/20 Foresight to overcome the chance of failure will be introduced and added to the 20/20 Hindsight technique. These techniques are already being used in some of the largest Megaprojects in the world, including those within Australia, typically in the Oil and Gas market.

With regard to the comparison of "*Risk*" associated with Collins and AWD, the change in "*Risk*" can be found in the analysis of the various changes associated with each of the parameters that characterise the two Megaprojects as identified in this superficial public domain analysis.

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1.8 CONCLUSION

"*The Noonan Method for Megaproject Risk Mitigation*" introduces a new structured and standard 20/20 Hindsight analysis method for completed Megaprojects. Using the "*Noonan Method*" Megaproject Performance can be compared between Megaprojects, no matter their type. Sources of "*The Megaproject Paradox*" that manifest themselves can be identified and compared. In this article the "*Noonan Method*" was applied to one past and one current Defence Shipbuilding Megaproject in Australia to highlight how a comparative analysis might be conducted to inform "*Lessons Learned*". The "*Lessons Learned*" can be used to inform 20/20 Foresight preparation for new Megaprojects such as the SEA 1000 Project Execution Phase of work. The "*Noonan Method*" can similarly be used for the Execution Phase of any other Australian Shipbuilding Megaproject. Some of the "*Lessons Learned*" are provided below.

- Australia is an Island, yet is still a continent sized country with a relatively small population, located at the foot of Asia. Australia has a unique set of Defence requirements as a consequence. Australia should take "*Lessons Learned*" from other countries in similar situations, and model its Defence Ship Building Industry on the most desirable model for Australia. Arguably, Australia can only afford to support one Government owned Shipbuilder. Australia should consolidate its Defence Shipbuilding investment in the ASC in Adelaide, Perth and other appropriate locations, as planned by the Australian Federal Government in the 1980's and supported in a bipartisan way by all subsequent Australian Federal Governments until Abbott became Prime Minister.

- There has been incessant bad press for ASC's AWD Megaproject in Australia during the Execution Phase. Using the analysis in this article, by 2016 the AWD Megaproject is arguably performing better than the Collins Megaproject using Project Cost Growth as a benchmark. Final comparison can only be made once AWD is complete after 2018.

- During the Collins Megaproject Execution Phase, ASC demonstrated an ability to leverage 12 global partners and 426 Australian Industry sub-contractors and numerous other sub, sub-contractors to design and build 6 Collins Class Submarines at ASC's Osborne facility in SA.

- During the Collins Execution Phase, ASC helped lift the number of Australian Companies with appropriate defence level quality control certifications move from only 35 in 1980 to over 1,500 Australian companies by 1998.

- ASC has successfully demonstrated its ability to provide ongoing maintenance in support of the RAN for the 6 Collins class Submarines for 13 years from 2003 with another 12 years remaining on the contract.

- RAN supported by ASC has demonstrated the quality and performance of the Collins class Submarines in repeated war games with the US and other Navies. The results

from these war games have demonstrated that the Collins are some of if not the best Conventional Submarines in the world.

- ASC has earned an enviable reputation for the design, construction, commissioning and Operational Maintenance and Support of Submarine and Surface Ships for Australia's defence on the high seas.

- The Australian Government has invested AUS$17 Billion over a 30-year period in cultivating the ASC as the focal point of Australia's Naval Ship Building Defence Industry Capability in support of the RAN.

- Economic rationalists, politicians and journalists all have very similar short term drivers when it comes to the analysis and public commentary on Megaprojects in Australia. These short-sighted drivers appear to be related to the short term Federal Election cycle in Australia. The key driver generally revolves around the very short sighted, myopic and immediate question "*How much does it cost*"? This is a simple question to answer, but the answer often bears no relationship to the complex story that needs to be understood before a commentary can be placed in context. "*Cost*" is after all, only one of the "*Noonan Megaproject Horizontal Parameters*" required for describing a Megaproject, and it is incredibly dependent on knowledge and understanding of the other 7 "*Noonan Megaproject Parameters*". The sensational negative reporting associated with the AWD Megaproject for example would have most people believing that this is a disastrous Megaproject. The reality is, when compared to Collins, AWD is performing very well. In turn, comparing both Collins and AWD to other globally executed Megaprojects, both happen to fall in the same company as 24.5% or 239 of the 975 Megaprojects studied by CII. Have either of Collins or AWD met the "*Owner's*" goal of "*predictable simultaneous achievement of Project Cost and Project Schedule*" in the Execution Phase? No, they have not met this benchmark. But Collins and AWD are part of the 95%, or 922 out of 975 other Megaprojects studied by CII from around the world that failed to achieve that very same benchmark.

- It is arguable that the "*Owner*" of the AWD Megaproject, the Australian Government, could shoulder most of the blame for any issues related to the construction of the 3 AWD Surface Ships for one reason. The key reason for any poor contractual performance manifesting itself as delay by the AWD Alliance is that the Australian Government took responsibility for Design away from the AWD Alliance and contracted a foreign Designer, Navantia. This decision was further compounded by placing no contractual accountability on the Designer for Design Changes that lead to construction delays by the AWD Alliance. The greatest Intellectual Property in the Construction of the AWD Surface Ships, indeed any ships, lies in the unique design of the ships. By giving that work to a Foreign Government "*Owned*" Shipbuilder, the Australian Government is losing significant Intellectual Property value from constructing the AWD's in Australia.

- It is extremely important for the "*Owner*" of the Megaproject to take control of the publicity associated with the Megaproject. The complexity surrounding the Megaproject is such that only the "*Owner*" can fully comprehend the story surrounding

the Megaproject. It is therefore only the "*Owner*" that can present a coherent story that places all point in time events related to the Megaproject into the context of the Megaproject "*Life Cycle*". Too often with Australian Defence Megaprojects, the "*Owner*" allows a vacuum of information to be filled by ill informed, short sighted or politically biased commentary that bears no relationship to actual Megaproject performance. The AWD Alliance has begun to address this publicity with appropriate use of regular Social Media releases as shown below.

https://vimeo.com/188766390

In Part 2.1 and Part 2.2 of the "*Megaproject Paradox*", real cost outcomes are considered for one recent Australian Oil and Gas Megaproject that failed to meet the "*Owner's*" predictability requirements and a second that has yet to emerge from the Preparatory Phases. In Part 3 of the "*Megaproject Paradox*" series of articles, new and structured methods of identifying, negotiating, and avoiding or overcoming the "*Megaproject Paradox*" issues are considered. The consideration uses the "*Noonan Method*" 20/20 Foresight analysis and other tools for "*Owners*" to prepare for Megaproject Success. Using a sophisticated "*Organisation*" Design Method prior to deployment of the Megaproject "*Organisation*", at each phase of the Megaproject "*Life Cycle*".

1.8.1 "*LESSONS LEARNED*" FROM PART 1

1. "*The Noonan Method for Megaproject Risk Mitigation*" is a method used to Design, Model, Simulate, Analyse and Verify that a Megaproject "*Organisation*" will deliver the Megaproject as required by the "*Owner*", prior to deployment of the Megaproject "*Organisation*".

2. Before the description of a Megaproject can be considered appropriately complete, it requires each of the "*Noonan Megaproject Horizontal Parameters*" identified in this article to be clearly defined, appropriately detailed and complete.

3. The use of 20/20 Hindsight identifies that 95% of all Megaprojects that have entered the Execution Phase around the world fail to achieve the "*Owner's*" benchmark for success.

4. The "*Owner's*" benchmark for success for a Megaproject requires "*predictable simultaneous achievement of Project Cost and Project Schedule*" in the Execution Phase..

5. The "*Owner's*" predictability target required for successful Megaproject Cost Growth in the Execution Phase is +/- 3%, while the predictability target for successful Megaproject Schedule Growth in the Execution Phase is +/- 2.7%.

6. While 95% of all Megaprojects fail to meet the "*Owner's*" benchmark for success, 70% of all Megaprojects fail to even hit a target of +/-10% Project Cost and Project Schedule Growth.

7. The "*Life Cycle*" of a Megaproject is typically measured in many decades or in the order of a century. Short term commentary on Megaproject issues by politicians

and/or media identities such as journalists quoted in traditional media are often misconceived, short sighted and ill-informed due to a lack of understanding of the "*Scope Complexity*" and where the issues sit in the context of the Megaproject "*Life Cycle*". These short-sighted comments in Australia appear to be very closely related to the Federal Government Election "*Life Cycle*".

8. Development of sophisticated Defence Infrastructure, the associated "*Organisation*" and local Industry Support required for fabrication of complex Defence Megaprojects such as Submarines requires non-partisan in country support from all political parties for a long-term strategy spanning a century or more.

9. There are two common denominators at the heart of all issues giving rise to the "*Megaproject Paradox*". Those common denominators are (i) "*The People*" involved in the Megaproject and (ii) "*Complexity*" of a Megaproject.

10. The use of "*The Noonan Method for Megaproject Risk Mitigation*" identifies the use of "*Organisation*" Design, Modelling, Simulation, Analysis and Verification which allows "*Owners*" of Megaprojects to mitigate the "*Risk*" of the "*Megaproject Paradox*" arising in their Megaproject Portfolio.

Please leave your comment below as your insights are greatly appreciated and a learning opportunity for everyone reading this article, including the author.

Other recent and popular posts on the "*Megaproject Paradox*" from John Noonan: Part 2.1: The Megaproject Paradox: What are the chances of a Barrel of Oil being $20 in 2020? Who will really care? • Part 2.2 The Megaproject Paradox: The Arrival of Peak Fossil Fuel Demand • Part 2.3 The Megaproject Paradox: Failure of a National Electricity Market • Part 3: The Megaproject Paradox: A Learning Tool for the Owner's Executive Leadership Team • Part 4.1.1 The Megaproject Paradox: Rule of the Game Number 1 - Megaproject Strategy • Part 4.1.2 The Megaproject Paradox: Rule of the Game Number 1 - Megaproject Strategy: BROWSE JV Strategy Analysis

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