# White Paper 2018-11

# How to Handle Large Complex Projects That Include Series Production

*Some types of Large Complex Projects include some aspect of Series manufacturing and/or construction. Examples include train rolling stock projects, large offshore windfarms, marine construction, recovery of nuclear waste etc. The concept can even be extended to the development project part of automotive or aeronautical projects. A substantial contribution to project success lies in the proper exploitation of the production learning curve as well as tight configuration management. Those specifics and some other aspects need to be considered from the start of the project. This White Paper gives an overview of the specific issues that need to be considered for those projects.*

## What type of Series should be considered?

Because a substantial Series Effect in the form of improved productivity can be observed within the first 3 sets of the production of any complicated item or the performance of complicated process, the concept of Series can be very large. It covers:

- Small Series (from 3 to a dozen sets),
- Medium Series (from a dozen to few hundred sets),
- Large Series (in excess of a few hundred sets).

It is important to note that depending on the level of possible customisations offered to the end client, large Series may have to be considered as medium series (and medium series small series) at least for a part of the item that is being built.

The concept of Series might also apply to only one part of the project such as a specific component or construction operation. Because the Series Effect offers generally such a huge gain of efficiency, all aspects of a project that can be standardised and repeated should be.

**Implementing a Large Complex Project that involves a Series, be it small, medium or large, requires taking specific steps to ensure the project delivers the maximum value**

## Factors of success of Projects involving Series Production

Projects that involve Series Production generally involve a prototype or pre-series (pre-series are supposed to be ultimately released for commercial use contrary to a prototype which is reserved for testing). Those first sets are generally used for qualification purpose, which can sometimes include regulatory approval. In parallel, Series production and/or installation is organised. Thus, it might happen that several sets be completed or in various stages of build prior to the approval of the type.

### *Learning Curve*

Series Effect will have a substantial impact on the overall project cost and schedule. Impact of learning curves can be very substantial, as shown by the naval industry, where gains of 40% or more in cost and schedule are expected to be obtained from the third exemplar for construction costs. Thus, missing the learning curve effect can have a disastrous impact on the overall project schedule and economics; while taking full advantage of it can create a substantial gain.

Depending on the project, some difficulties might hinder the learning curve effect:

- Capacity issues might require construction or manufacturing to occur on several sites in parallel; in that case an intense lessons-learnt and information exchange process must be available,
- In case of construction followed by installation, or any situation where the series happen in several distinct steps, the overall system must be balanced, accounting for possible variations in the execution rates for each step. In this classical dependent event problems, teachings from the Theory of Constraints about bottlenecks apply in full. Operational models must be developed to minimise inefficiency and most importantly a conscious decision must be taken as to at which step the bottleneck of the system should lie.

### *Configuration management*

Changes can be expected between the first set and the last set:

- Tests performed on the first set might lead to changes being implemented on the Series,
- During the time spent building the Series, lessons learnt from actual construction and operation of the first sets or from other projects with similar sets might require changes to be implemented,
- External requirements may change during the Series construction – although the project definition should have anticipated them as much as possible, and type approval by regulatory authorities should make it possible to avoid most of these effects. However, this might happen for example in very long projects such as in the nuclear industry.

It is essential to maintain a tight Configuration Management process linked to a comprehensive Management of Change process. Changes must be implemented in a limited number of batches and full visibility on the configuration of each set must be maintained. Projects can quickly become extremely difficult to control if configuration is not managed

properly: observed performance issues cannot be related to configuration, learning curve effects disappear and it becomes impossible to properly plan interventions for preventive or corrective maintenance.

### *Commissioning and testing focus*

Since the testing and commissioning of the first set is so important because of the possible consequential impact on the configuration of the rest of the production, this process must be integrated from the start of the project. Tests should be anticipated as much as possible to investigate potential unknowns and obtain early knowledge of any issue that would require changes to be implemented. The sequence of commissioning and testing should be particularly reviewed with this issue in mind. In that respect, the decision whether to implement a technology demonstrator, a prototype, or produce straight a pre-series should be considered carefully. It might sometimes be less expensive and risky to produce a prototype or even a demonstrator of key technology early that allows to iron out issues prior to the full-fledge Series production.

**The prevention of generic faults or defects must be an essential focus and reliability engineering must be deployed in a comprehensive manner**

## Other Aspects to be Considered Carefully When Planning Projects Involving Series

Several aspects must also be carefully considered when planning projects that involve Series. Most are related to capacity issues to make sure that the Series effect / learning curve will deliver its full acceleration potential without being blocked by a bottleneck either at the start of at the end of the production chain. Although simple to understand this might require a substantial change of logic and practice for organizations that are used to large projects of one-off items.

### *Supply-Chain considerations*

Supply chain organization and supplier capability must be considered differently from requirements for projects without Series. The acceleration of production during series production must not be hindered by a capacity issue on the supplier side.

Ideally, suppliers should have the capacity to deliver just-in-time to minimize stock (carried inventory, hence financial impact) and the risk of obsolescence. Conversely if there is a capacity risk, production of supplies must be anticipated; however, this carries the potential issue of producing items that become obsolete should a change be required.

Suppliers must also be able to enforce a strong configuration management process including for all spare parts and internal parts for systems and equipment, and this level of detail should be covered as well in the final configuration management system.

### *Reception process by Client*

The reception process by the Client must also be able to face capacity-wise the rate of delivery to be expected if the full Series effect is delivered successfully. This might require the contracting of temporary help, and in any case, this requires a thorough planning that can adapt to the delivery rate. A maximum delivery rate should be contractually agreed to allow all parties to adapt their organization, process and resources accordingly.

### *Specific importance of reliability analysis to avoid generic faults*

Reliability analysis is even more important than for one-off production because of the risk of generic faults. The main risk of any Series is a generic fault that requires to change one or several components over the entire fleet and might even lead to grounding the entire fleet with huge consequences for the Client. Reliability analysis has key consequences on:

- Warranty coverage. While the exposure will depend on the contract, generic faults must be avoided since it will have substantial consequences on the client operations,
- Capital spare parts. Final deliverables are often delivered with a set of spare parts called capital spare parts and that typically cover an estimated 2 years of operation, plus some critical spare parts for special components. It is possible to optimise the carried inventory by taking into account a fleet view, however this must be carefully analysed from the reliability perspective.

## Conclusion

Implementing a Large Complex Project that involves a Series, be it small, medium or large, requires taking specific steps to ensure the project delivers the maximum value. Those steps can have very significant structural consequences on the full value chain of the project. Most importantly, capacity issues must be carefully analysed to make sure the project understands and anticipates potential bottlenecks. Finally, the prevention of generic faults must be an essential focus and reliability engineering must be deployed in a comprehensive manner.

.