ROLLING WAVE DEFINITION: BENEFITS, CHALLENGES AND RELATED PROJECT MANAGEMENT PRACTICES

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Abstract: A critical exercise during project initiation and execution is to balance the need for flexibility and the need for a controlled scope, so that the project can be adapted while remaining on track. This is particularly important when the PoW (Plan of Work) of projects is becoming shorter and while industrial constraints such as vessel availability or manufacturing slots, as well as permitting scope and duration can make a project quite sensitive to variations of initial hypotheses.

1. INTRODUCTION

While, during project initiation, baselines are set about key projects parameters such as scope, time and cost, a number of points usually remain to be refined at the start of the project. This progressive, or 'rolling wave' [1] definition, is related to factors which will be reviewed in this paper. The clear planning, assessing and watching of these steps of definition will also be discussed.

A first reason why a progressive definition is needed is the practical nature of our activity. Some tasks, like marine or landing site surveys, must be performed before the details of the subsequent activities can be known. These different stages will be reviewed.

Also, the project realization may need to be launched with some important options remaining open, for example the addition of branches, so that the related business opportunities or agreements could be assessed or finalized while the main part of the project is starting. Therefore, usually, contracts include some options, with deadlines for them to be exercised.

Additionally, due to external unpredicted causes or a commercial desire to grasp some unforeseen opportunities, the project may consider taking on board some modifications during the realization, which were not originally considered as options. As will be discussed in this paper, the impact of unplanned changes can be huge and must be carefully considered.

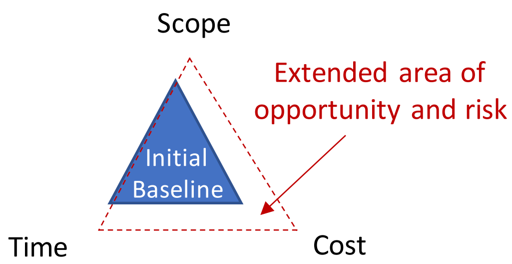

Figure 1: Triangle of key interrelated baselines

The progressive definition of the project scope, during initiation and during the start of project execution, has inevitably some impact on the time baseline (Plan of Work) and on the cost baseline. This is depicted in **Figure 1**, with the usual triangle to show that one key baseline of a project can usually not be modified without moving the other two. Additionally, when changing the triangle shape, the opportunity and the risk should be analysed and weighed up before making a decision about the modification.

For example, there might be some pre-agreed impact, in terms of cost and PoW, associated with deciding to keep an option open for some time, but which would be outweighed by the expected benefits. As another example, increasing the scope by adding an unpredicted branch could have a significant impact on the time needed to complete the project and on the costs.

Indeed, in our industry, the interrelation between the scope, time and cost are mostly driven by activities and domains which are ‘non-linear’, meaning a small modification of the hypothesis can induce a large impact. As depicted in **Figure 2**, these critical aspects are:

- Permitting: survey, in principle, operational
- Resources: availability of vessels, industrial aspects such as lead time and manufacturing slots

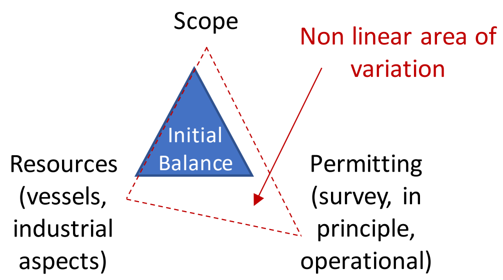

Figure 2: Triangle of key drivers while assessing impact of scope modification

The objective of this paper is therefore to discuss which are the typical points progressively defined during a project.

Also, it provides some insight about the assessment of the impact of changes and emphasises leverage effects which in some cases mean that relatively small changes or delays have huge consequences in terms of PoW and cost.

All of that, of course, has to be weighed against the benefits of flexibility and of change, which can equally be of great significance for the project and for the related business.

2. PROGRESSIVE DEFINITION STEPS

2.1. Typical sequence

The typical sequence of activities in a project is commented below and is summarized in **Figure 3**. These steps are detailed in **Figure 4**. and further commented in the following sections.

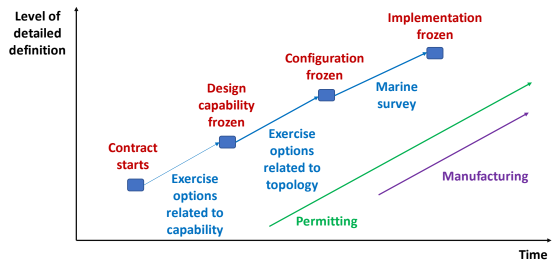

Figure 3: Increased level of detailed definition over time

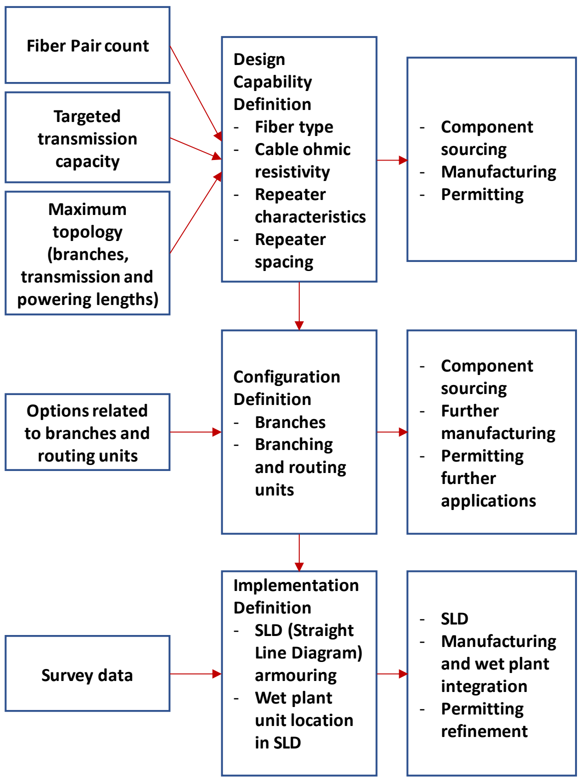

Figure 4: Typical sequence of system characteristics definition

2.2. Contractual obligations start

This is when, at the end of a (usually) competitive supplier selection process and a definition phase between the supplier(s) and the Purchasers, the basis of the system definition and the options are agreed. Contractual aspects such as down payment, billing schedule, guarantees and bonds are set and the clock starts to tick.

2.3. Design capability definition

Design capability is a relative matter since the transmission technology evolves over time but it can be defined as the fundamental resources of the system, namely:

- The maximum topology and maximum transmission length
- The fiber pair count
- The repeater characteristics such as bandwidth
- The system OSNR/GOSNR [2].

This design capability of the system typically translates into the definition of key network parameters such as repeater spacing, fiber and cable characteristics, as well as electrical powering requirements. These system features are interrelated and must be optimized. Recently, such optimization has evolved towards favoring the global system capacity rather than the per-fiber-pair capacity, in order to optimise the use of the electrical powering [3, 4].

Specifically, the spacing between repeaters and the maximum achievable length of the system are interdependent aspects that need to be considered in tandem. While it depends on the contract and project arrangement, quite often an early assumption of the repeater spacing is needed, to launch some component definition and sourcing or to start some manufacturing before the actual total length is known. The total system length, that means the length of the longest transmission path, is defined in steps, starting from desktop studies up to the completion of the marine survey and route engineering, when the final length is known.

The system maximum length, the related repeater count and the fiber count (hence the count of amplifiers and of pumps in each repeater) also have an influence on the electrical powering requirement. Because the required number of fiber pairs has recently been drastically increasing, electrical powering is becoming a critical matter of design.

2.4. Configuration definition

In the typical sequence described here, the configuration of the system is frozen when the options are exercised, typically the options related to the topology and the connectivity.

Options can be related to the implementation of a Branching Unit (BU), of a branch, or both as represented in **Figure 5**. At this step, the BUs and the branches to be implemented are defined and the manufacturing of such submerged units can be launched.

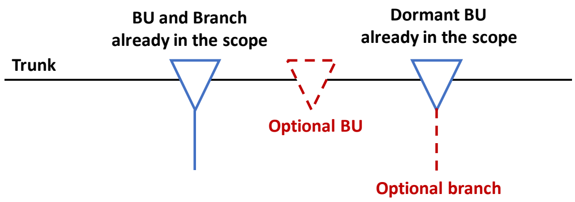

Figure 5: Typical optional cases related to Branching Units and branches

As a simplification, thanks to the recent advent of more and more flexible Branching Units, either at the wave level or at the fiber level, some internal details of such units have become generic and configurable, so do not require specific definition before manufacturing. This has removed one of the early definition milestones. Indeed, previously, with ROADM (Reconfigurable Optical Add Drop Multiplexing) units based on switchable fixed filters, it was necessary to agree very early about the exact wavelength routing. This is no longer necessary thanks to the advent of WSS (Wavelength Selective Switch) submerged units.

2.5. Implementation definition

Key additional information is brought by the landing site surveys and the marine survey, namely:

- The final route
- The constraints related to the location of the wet plant units
- The cable armouring need along the route.

Specifically, in addition to the work already done during the desktop studies, the repeater and Branching Units location can be further confirmed, to deal with constraints such as the crossing of other cables or seabed characteristics.

Finally, all this information enables the consolidation of the Straight Line Diagram (SLD), in order to build and integrate the adequate cable sections in terms of length, attenuation, armouring and transitions.

2.6. Dry plant definition

While the main purpose of this paper is to address the wet plant aspects of submarine network projects, for the sake of a consistent picture, some key elements of the dry infrastructure are also worth addressing.

Indeed, even with the advent of so-called ‘open cables’ – designed to connect terminals which have shorter lead time than the cable and which can be relatively easily added or modified after the system is implemented – there are still some key dry or land resources which have to be defined early enough so that the system can be used at ‘Day 1’.

The project PoW, once the project is initiated, usually allows some time for these aspects to be jointly defined between the Purchasers, the supplier and third parties (such as landing station or land owners).

The exact landing points and Beach Man Hole (BMH) locations, which are at the edge between dry and wet activities, can be determined following site surveys and permitting studies. The land route, the station location and the system earthing approach have also to be determined following assessment such as re-using existing infrastructures or building new ones. For example, if the landing site survey determines that, for system earthing, sea earth plates have to be used instead of rods, it can require a different approach to permitting.

The definition of the dry plant requires the definition of other technical specific aspects such as whether the Power Feeding Equipment (PFE) and the submarine transmission terminal are co-located and whether a backhaul link is part of the end-to-end transmission, possibly including some protection features.

This progressive definition is quite common but has to be carefully embedded in the PoW and the milestones have to be carefully watched.

Even if all aspects are not fully defined at the outset, some hypotheses may have to be made early in the programme, for example the maximum length of the land route, in order to feed the design capability freeze. Typical interactions with other design domains are depicted in **Figure 6**.

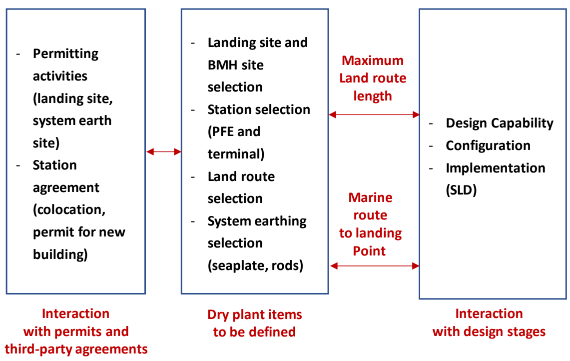

Figure 6: Interactions between dry plant definition, overall design stages, and permitting activities

3. CHALLENGES OF PROGRESSIVE DEFINITION AND FLEXIBILITY

3.1. Need for flexibility

The need for a progressive definition, which can also be seen as a form of flexibility, should not be seen as an adverse necessity only bringing risk into the project but rather as part of the project scope and the normal project course of events.

Indeed, some part of the flexibility is imposed by the operational nature of the activity, since achieving some preliminary tasks is necessary to fully define the next steps.

As another benefit of flexibility, options such as adding more fiber pairs, or adding a branch, are quite often easier to materialize once the project has started and has some momentum. Indeed, investors or customers can be further approached by the initial core of Purchasers while the project has been initiated around a base design. Therefore, such options are quite often embedded in the contractual agreement.

Introducing flexibility is sometimes also necessary for the project to overcome some issues, like an unforeseen permitting or authorization issue, or to grasp an unexpected opportunity.

The following sections intend to discuss how to best deal with this flexibility.

3.2. Need for clarity and for joint understanding of the implications

While it may seem obvious, it requires a great deal of attention to make sure there is a common understanding, among the project stakeholders, of what is frozen, of what is still expected to be defined, and of what would be a completely unexpected modification. Assumptions must be uncovered and options must be clearly defined, with clear boundaries and exclusions.

As part of this definition exercise, in the case of shared responsibilities, a clear matrix of responsibility helps to prevent any gap or delay.

The clarity of the progress and a sound communication are also critical. Therefore, it is necessary to keep a carefully updated description of the baselines.

In particular, when the definition of a point is being discussed, it is useful to take into consideration to which of the following categories it belongs:

- Mandatory progressive definition: this is the progressive definition induced by the nature of the activity. Indeed, some aspects can only be defined once some of the first project activities have been achieved, typically the surveys. The steps of this progressive definition are embedded in the initial PoW. Milestones have to be defined with clarity and setting the initial deadlines require a comprehensive initial PoW analysis. Once refined information (exact route, exact landing site, system earth approach for example) becomes available, the impact has to be assessed and taken into account in the baselines.
- Planned initial options: these are high level system characteristics which virtually could have been decided at the project inception, but whose decision required more time, usually for reasons related to business development. Typical examples are optional branches or additional fiber pairs. Such options also have a deadline embedded in the initial PoW. Since planned at the outset of the project, such clearly defined options are in fact managed as part of the mandatory progressive definition.
- Unplanned change requests: it can be an additional unplanned option to take benefit of a new opportunity (like adding a branch) or it can be a modification to work around an

unexpected issue (for example changing the landing point due to a local authorization issue). A quite thorough analysis is then required, as well as making sure the impacts are well understood by all stakeholders. The outcome of the analysis could be to accept the modification, or not to proceed with the change request at least for this project phase.

For each of the different types of flexibility listed above, a comprehensive analysis is needed, in terms of cost, PoW, risk and opportunities, as illustrated by **Figure 7**.

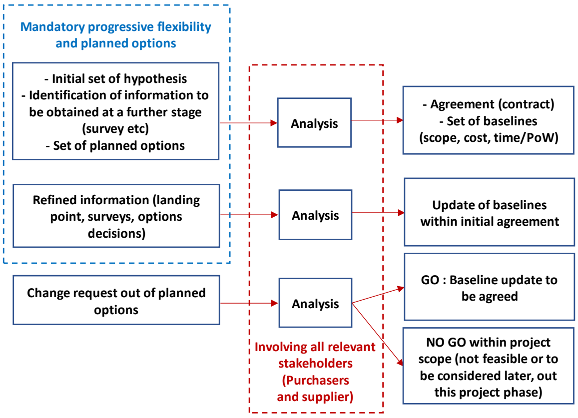

Figure 7: Setting and adjustment of baselines based on initial or refined hypothesis and change requests

The above-mentioned analysis of the impact of a change request is one of the most vital activities of any project management, not only for submarine cable projects. However, in the case of our industry, there are specific domains, namely permitting and resource constraints, which have to be duly visited, as discussed below.

3.3. Permitting and Environmental Impact Assessment (EIA)

Permitting and Environmental Impact Assessment are activities with a duration which can be both long and somewhat uncertain, since it is related to multiple interactions with external bodies. It is quite often on the critical path of projects so this subject requires the utmost attention.

The process and the time needed are obviously highly dependent on the project detailed scope, especially in terms of configuration, as highlighted in **Figure 8.**

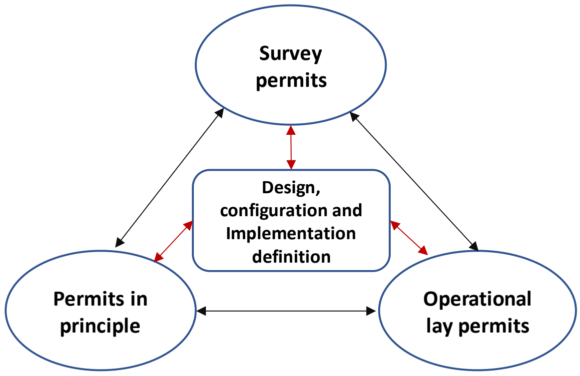

Figure 8: Interactions between permitting activities and overall definition stages

Due to the long durations involved, and often the requirements of the relevant authorities, permitting is an activity that demands that the network configuration is frozen early. It also demands a careful PoW analysis, especially in terms of dependencies, in order to define the milestones when options have to be exercised.

In terms of Permits in Principle, depending on the specific regulations of the countries and areas involved, it may be necessary to announce the global description of the potential network connectivity and its purpose at a very early stage. Hence, potential future branches may have to be described from the beginning of the permit application.

Therefore, to keep open the option for a branch, it may be necessary to include it in the initial permit request, which may delay the overall process if all data regarding the branch are not available, or if the permitting process related to the branch is particularly long.

Another approach could be to start the permit process for a branch only when the option for this branch is exercised. That could be beneficial if the permitting processes are well separated for the branch Vs. the rest of the network, and if there is available time to manage the branch permit process.

The management of branch options is also important in terms of operational permits for survey and in practical terms of survey operations. It is obviously beneficial to decide for the branch early enough so that combined survey operations are possible for the main baseline scope and for the optional branch. That would also allow for combined manufacturing, freighting and marine lay. If the branch is not certain it could still be worth surveying the BU box location whilst the survey vessel is on site as the marginal cost is moderate but the potential benefit could be higher

In the specific cases when post-survey data is necessary to feed the Permits in Principle, this adds a further dependence to be taken into account.

3.4. Resource constraints

Submarine cable networks are using industrial resources where the availability constraints can induce ‘non-linear’ impacts. A small variation of the assumptions can induce a large impact, with a leverage effects.

For example, missing the date when a branch had to be decided could induce a cascading domino effect in terms of PoW: the planned survey vessel may then become unavailable, hence the survey data may be too late for the permit submission and/or the planned manufacturing slot and that may finally mean a delay impact much larger than a 1:1 day slippage. The same reasoning may apply for a deferred decision regarding an option involving components whose sourcing lead time may vary over time.

In general, as depicted in **Figure 9**, the cascade of such interdependent tasks whose duration would be dependent on the triggering date, could lead to a broad range of dates, far away from the nominal reference case. When possible, in practice, instead of a ‘let-it-be’ approach, a more deterministic and a step-in attitude are considered, typically by bringing additional resources to help save time in case, for example, of a late decision for an option. That may mean to buy material with a premium to shorten the lead time, or to mobilize an extra vessel, both involving extra cost. The costs and benefits should be weighed and shared with stakeholders of the project, on both Purchasers’ side and supplier’s side.

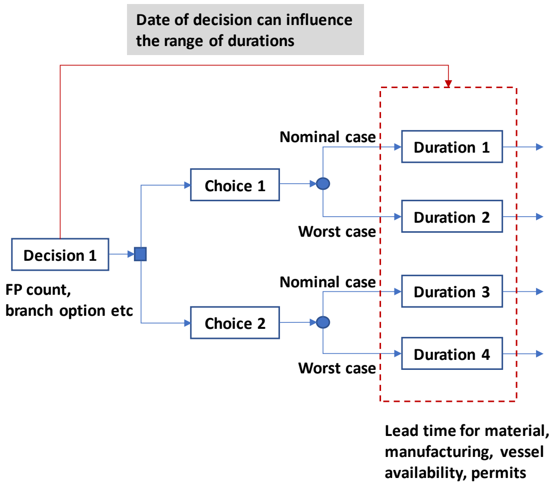

Figure 9: Typical tree diagram showing effect on PoW of decision gates and of uncertainty Vs. paths

These leverage effects should be taken on board for the three types of progressive definition situations which were listed: while determining the deadline for progressive information to become available, while investigating the deadline for an option to be exercised, or while assessing the impact of an unplanned change request.

On a more positive note, and more generally than for the PoW aspects, such amplification effects of a cause would also apply for opportunities where adapting the project scope to grasp a possibility may provide a larger benefit than the initial adaptation effort. Typically, adding a branch and taking on board one more key investor can be of great benefit for a group of Purchasers and for the future business over the life of the system.

4. CONCLUSION

We have seen that a progressive definition and some flexibility are necessary during the implementation of a project, both by nature of the activity being progressively elaborated, or to allow for further business opportunities to be taken on board during the starting phase of project execution, and also to deal with some requested modifications or issues.

However, before introducing some flexibility, a very careful analysis of the possible impacts, integrating all aspects of the project, is necessary. A key matter is the dates when some actions and some decisions are needed. The point of timely decisions is of particular importance, since missing a deadline may induce consequences much larger than the cause, due to leverage effects that apply to our industry, like vessel availability, permitting or manufacturing slots.

We then reach a matter of risk and opportunity management, which has to be openly shared with the different project stakeholders, on both Purchasers' and supplier's sides. Targeting to decide in advance about options, with respect to the planned deadlines, is for example a sound practice which allows the risk to be reduced and can provide more room to manage unplanned change requests.

Unplanned change requests have to be analysed on a case by case basis, and dealing with them can require consideration of numerous scenarios, involving extra time, cost and risk but also opportunities.

In a nutshell, flexibility is not an adverse element to a project. It can actually be beneficial and contribute to its commercial success. However, to reach the best outcome requires a sound integrated analysis of all project aspects, as well as some discussions and agreements between the supplier and Purchasers. It involves taking care of the communication and stakeholder engagement on both Purchaser and supplier sides.

5. REFERENCES

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