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DEFINITION OF A VIRTUAL TEST BUSINESS SCENARIO FOR LCC SIMULATION IN LINE WITH ACARE

by

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Abstract:

This document presents the work done by WP2.2 members in preparing a virtual test business scenario for LCC simulations. Four examples of business case scenarios are presented, where LCC modelling is used in different ways, and among these four one scenario is chosen for the LCC model validation.

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1. EXECUTIVE SUMMARY

This document presents the work done by WP2.2 members in preparing a virtual test business scenario for LCC simulations in line with ACARE.

We find that the standardized LCC model will contribute to the HLO (High Level Objectives) of VIVACE in reducing lead time and thereby also cost, and it will also contribute to data traceability by the standardized format of the LCC data.

In this report we present four examples of business case scenarios where LCC modelling is used in different ways, and from these four we choose one scenario for the LCC model validation.

2. DEFINITIONS AND ABBREVIATIONS

For reducing the risk of misunderstandings in this type of project it is important that there is a common agreement/understanding regarding the fundamental definitions and abbreviations. The following terms will appear in this report:

Validation	To show/demonstrate that a solution or process is correct.
Use Case	A Use Case describes a system, defining an overall vision of organizations, processes and high-level capabilities of the system. The use case is made up of a set of possible sequences of interactions between systems and users in a particular environment and related to a particular goal.
Scenario	A scenario is an instantiation of a use case, which means describing how the use case system behaves in different situations
ACARE	A dvisory C ouncil for A eronautics R esearch in E urope
HLO	H igh L evel O bjectives, the overall goals of VIVACE in line with ACARE
LCC	L ife C ycle C ost, the overall cost for an engine, from the early pre-development phase to life termination
WP	W ork P ackage

3. WORK CONTEXT

3.1. SHORT DESCRIPTION OF WP2.2

Two of the High Level Objectives (HLO) of the VIVACE project are to reduce the lead time by 30 % and the development cost by 50% for a new or derivate gas turbine.

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In Life Cycle Cost analysis all costs related to the overall gas turbine life time, from the early product development phase to the life termination phase are gathered, and by testing different solutions for different life cycle phases you can choose the most economical solution, and this supports the HLO of reducing costs. Moreover by using a standard LCC-model that is to be used by all partners you reduce lead time. You don't have to discuss and agree on the cost structure between all parties every time, and that supports the HLO on reducing lead time, and since time is money this also contributes to a lower development cost. For example it reduces the number of travels for meetings.

In Work Package WP2.2 there are three main subtasks:

1. **T2.2.1 Life Cycle Cost (LCC) Nomenclature & Structure**
In this task the work is to define a nomenclature and structure for LCC analysis to be used by partners in developing new or derivate gas turbines. In M12 the delivery was to define the structure until a third detail level, and at M24 to fulfil the task, a fourth level is to be defined.
2. **T2.2.2 LCC Modelling for Business Simulation**
This is the task where the LCC model is created. The model is to be phase oriented and input to this task is the main cost drivers that are defined in WP3.3 Subtask 3.3.3.4 Cost Modelling.
3. **T.2.23 Model Validation**
To provide confidence within the VIVACE project the validation of the model is important, and for this purpose a validation task is specified. See more detailed description in §3.2.

Subtask ST3.3.3.4 Cost Modelling in WP3.3 is very tight connected to WP2.2 since the output from this task is a crucial input to T.2.2.2 LCC Modelling for Business Simulation. The task is to identify the main cost drivers for LCC modelling, and to specify the correlations and dependencies between them, in connection to the LCC structure. These parameters will form the basic data for Task2.2.2, Modelling for Business Simulation.

3.2. TASK 2.2.3 MODEL VALIDATION

The validation of the model is very important to provide confidence within the VIVACE project and the customer. The validation will be done with a business simulation of a given virtual business scenario and an agreed aero engine architecture. This report will present the first definition of the chosen business scenario.

We have had some difficulties to define the work and the expected output of this task, since it is somewhat indistinctly described what is expected / possible to be validated about the LCC model. Is it to validate that the new LCC model...

- is correct?
- is better than "As Is"?
- reduces cost?
- makes collaboration between partners in a "Virtual Extended Enterprise" more efficient?
- shortens the lead time in product development?

To validate that a LCC model is correct is very difficult and time consuming, since to be sure you would have to wait until after the end of the life time of the product if you really want to know all the costs during the whole life time. And to evaluate all the costs, you

have to have access to all costs from the early phase of product development through all phases until life termination cost, and that is probably a utopia to get all these figures gathered. And without having all figures you can't show that the model is really correct.

To validate that a new model is a better model than "As Is" is also difficult since the models used today differs between different partners in a gas turbine program and it is very difficult to translate or reshape all figures into a different cost element structure in a new model, because you have to know the content of different cost elements in different models in details. And most often you don't have that detailed documentation of all costs during all the phases of the life cycle of an engine that is detailed enough to reshape into another cost element structure.

To validate that the new model is reducing the LCC costs by itself, just being a better model, is that the aim? It would be very difficult to show that one model brings lower cost by a "smarter" structure, or by other math models, since you need to have something to compare it with. The way you probably can lower the cost by a new LCC model is that it is a standardized model, both in structure and nomenclature.

By creating a standardized LCC model you get more advantages than a better overview of the costs. You also facilitate the cooperation between partners in gas turbine programs, for example in partner agreement, in product development and proposal to customers, since you save a lot of time by fewer discussions about the content. And with an easy overview of the LCC costs you can more easily compare different concepts during product development, and by that save both time and money in the overall LCC costs.

The conclusion of this reasoning is that it may be possible to validate the last items in the list above, by validating that an LCC model with a standard structure and nomenclature saves time, and by saving time you also save money. And to validate the time saving the most illustrative way to do that is to show the difference between As Is and To Be with some kind of process description, a use case scenario.

4. USE CASE AND SCENARIOS

4.1. INTERPRETATION OF USE CASE AND SCENARIO DEFINITIONS

In the VIVACE project the terms Use Case and Scenarios are frequently used, but it has been difficult to have the same interpretation of the terms. Therefore our interpretation is presented in this report to prevent misunderstandings.

Use Case - A Use Case describes a system, defining an overall vision of organizations, processes and high-level capabilities of the system.

The use case is made up of a set of possible sequences of interactions between systems and users in a particular environment and related to a particular goal.

Scenario - A scenario is an instantiation of a use case, which means describing how the use case system behaves in different situations.

4.1.1. Use Case and Scenarios for LCC model

A Use Case for LCC modelling could be to define the project for the development and manufacture of a specific product, for example a jet engine for a commercial aero plane with four engines for long distance flights, and it will be a business

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project with four partners etc. The standard LCC model can be used at different occasion during the engine life time, but you use different parts and not the same level of detail in the analysis at these occasions and we therefore consider them to be our scenarios, i.e. instantiations of the use case.

It is not obvious how to choose Use Case and Scenarios for this LCC model validation task. One way is to define the different occasions when you use the LCC model as use cases and choose different engine project as scenarios, but since we observed that we use different parts and different detail levels of the LCC model at different occasions, we choose to define a specific engine project as a use case and the different LCC cost estimate occasion as the scenarios. Since it is the benefit of the use of a standard LCC model we want to validate, we get a better validation of the LCC model this way.

4.2. DIFFERENT LCC SCENARIOS DURING THE ENGINE LIFE CYCLE

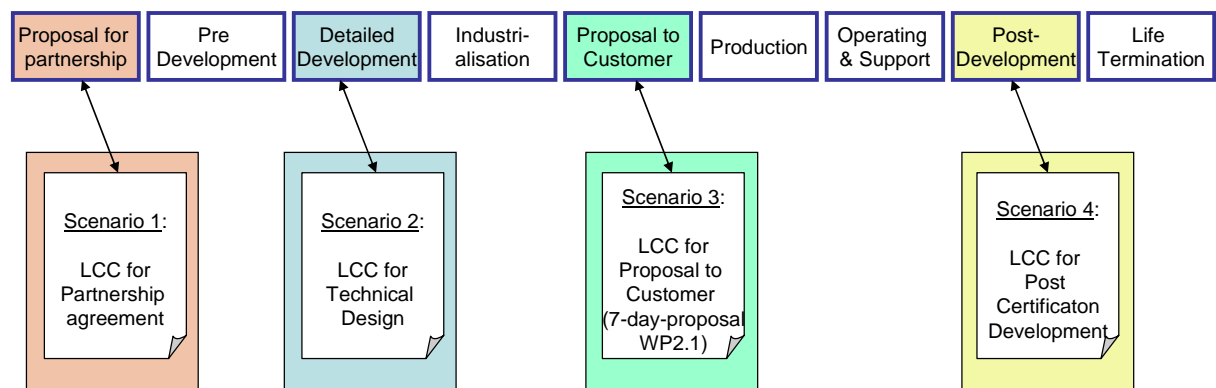
During an engine life cycle there are many occasions where it's important to make cost analysis. Sometimes you do a complete Life Cycle analysis, sometimes you do partial analysis using different parts of the total LCC structure. According to our interpretation of Use case and Scenarios we consider these different occasions of engine cost analysis as different Scenarios.

We have chosen four different scenarios to describe in relation to our LCC nomenclature and structure model. They are:

1. Proposal for Partnership/Partner agreement
2. Chose Concept/Design in Product Development
3. Proposal to Customer (7-day-proposal)
4. Changes in Design in Post certification Development

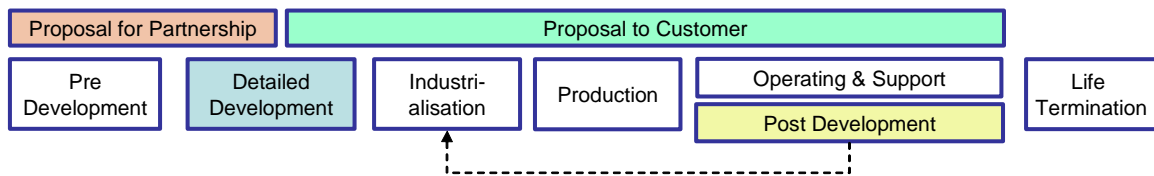
In the figure below, the phases of the engine life cycle in our standardized LCC model is complemented by two marketing phases; Proposal for Partnership and Proposal to Customer.

Please observe that this is not a chronologic chain; it is only a symbolic presentation of the life cycle phases plus some of the marketing activities concerning the engine!



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In the figure above it may look like the marketing phases/activities appears between the engine life cycle phase but that is not quite true, it is just a more practical symbolic way to explore them. The marketing phases actually appear more like in the figure below (which is a part of Figure 1 in paragraph 6 at the end of this report). Different LCC phases are not appearing one at a time as it looks like above, and some phases are iterative; when a Post Development occurs at any time after the product certification you will have to go through the Industrialization and Production phases again to get the new engine design into the Operation & Support phase.



But this figure is not really true either because more of the phases are overlapping, for example the industrialization phase begins quite early during the development, the production can continue after the first engines have entered the operation & support phase, but the extent of overlapping differs and the figure becomes more complex so we will use the symbolic layout with all phases/activities in a single line in our presentation of the scenarios since it is a more practical layout for this purpose.

For these scenarios we have found that you use different levels of detail, which mainly depends on how early in the engine life cycle you do the analysis. The earlier the analysis is performed the fewer details you have access to. And you may also use different parts of the total LCC structure, depending on the purpose of the analysis.

And who (which partner, OEM, supplier etc) is making which part the analysis also differs, principally depending on the type of business concept. That matter we have not fully studied in this subtask since it is complex and more business related than LCC-related, but we present some reflections about that matter in our scenario presentations.

We describe the relation between the “LCC Structure / Levels” and the four scenarios, and we show a more graphical description of the relation in Figure 3, at the end of this report.

4.2.1. Scenario 1: Proposal for Partnership / Partner agreement

Name: Proposal for Partnership / Partner agreement

Purpose: The purpose of this cost analysis is to decide weather to go into a new engine project with other potential business partners.

Processes - As Is:

1. Each partner creates individual Business proposal with Work Packages Structure
2. Individual Cost Estimation
3. Agreement on WP Structure & Content (by iterations 3-6)
4. Individual update of WP by each Partner
5. Individual update of Cost Estimation

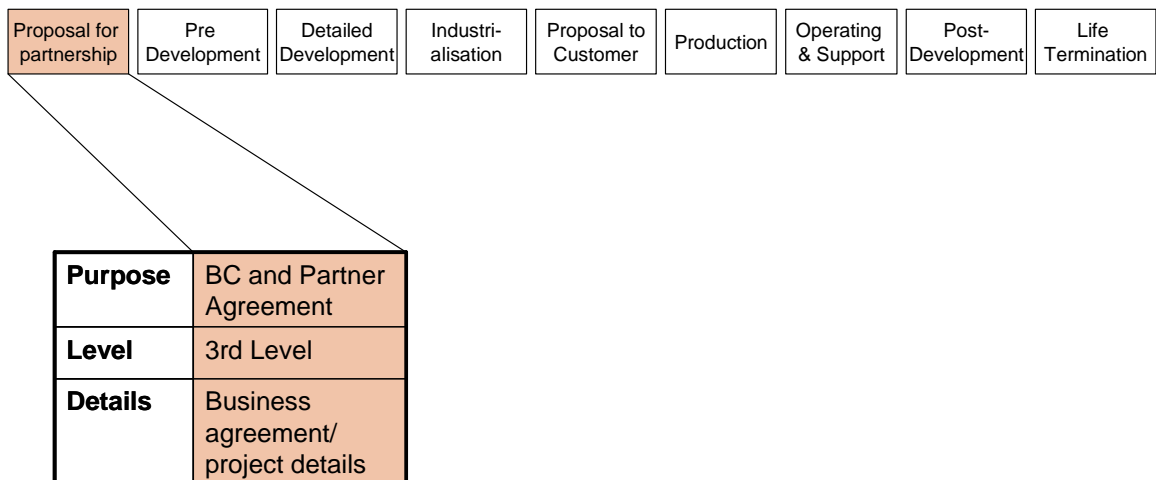
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6. Discussion on assumptions & Cost Estimation results; iterations back to §3 as many times as needed for agreement.
7. Agreement on Partnership

Processes – To Be:

1. Agreement on Standardized Work Packages Structure according to LCC model
2. Discuss & agree on specific complements and exceptions/changes
3. Individual Cost Estimation
4. Discussion and Agreement on Partnership

LCC Structure / Level: This cost estimation is done quite early in the engine life cycle and therefore you don't have much real/detailed data, so you have to do the analysis on a rather high aggregated level, probably you have to satisfy with Level 3 in the LCC structure. Of course you can use Level 4 data if any details from that level are known this early in the project, but level 3 is more likely for the whole analysis.



4.2.2. Scenario 2: Concept/Design Decisions in Product Development

Name: Concept/Design Decisions in Product Development

Purpose: During both Pre-Development (early development phases with technology and concept studies etc) and in Detailed Development you use the LCC analysis to make technical decisions of concept and design. To develop the most economical engine you have to look at the overall costs during the whole lifetime, and it is during the product development phases you can influence the total engine cost the most.

Processes - As Is:

1. Each partner creates individual Module breakdown structure
2. Individual Cost Estimation per concept
3. Agreement on Module Structure basic assumptions and cost (by iterations 3-6)

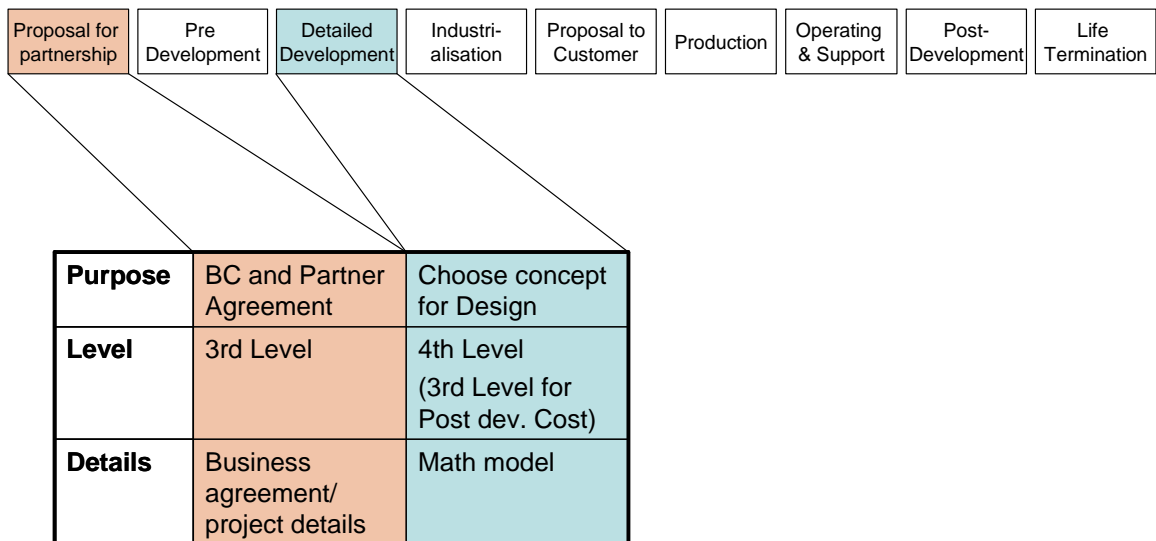
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4. Individual update of Module breakdown structure and content by each Partner
5. Individual update of Cost Estimation per concept
6. Discussion on assumptions & Cost Estimation results; iterations back to §3 as many times as needed for agreement.
7. Agreement on concept and cost estimation results

Processes – To Be:

1. Agreement on Standardized Module breakdown Structure according to LCC model
2. Discuss & agree on specific complements and exceptions/changes
3. Individual Cost Estimation
4. Discussion and Agreement on concept and cost estimation results

LCC Structure / Level: During the product development phases the information of Level 4 is becoming more and more available. The aim is to have a total Level 4 analysis for the best basic data for technical decisions.



4.2.3. Scenario 3: Proposal to Customer

Name: Proposal to Customer (7-day-proposal)

Purpose: The purpose of the cost analysis is to show a potential customer the business case and total cost for the engine in the customers view.

In Work Package WP2.1 they are working on a method for a “7-day-proposal”. The purpose is to analyze and develop a method for Proposal to Customer in a much

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shorter time than today. One of their needs is to have basic data for proposal standardized, for example LCC data, and since our Work Package aims to create a standard LCC model there are connection between our WP's in this scenario.

Processes - As Is:

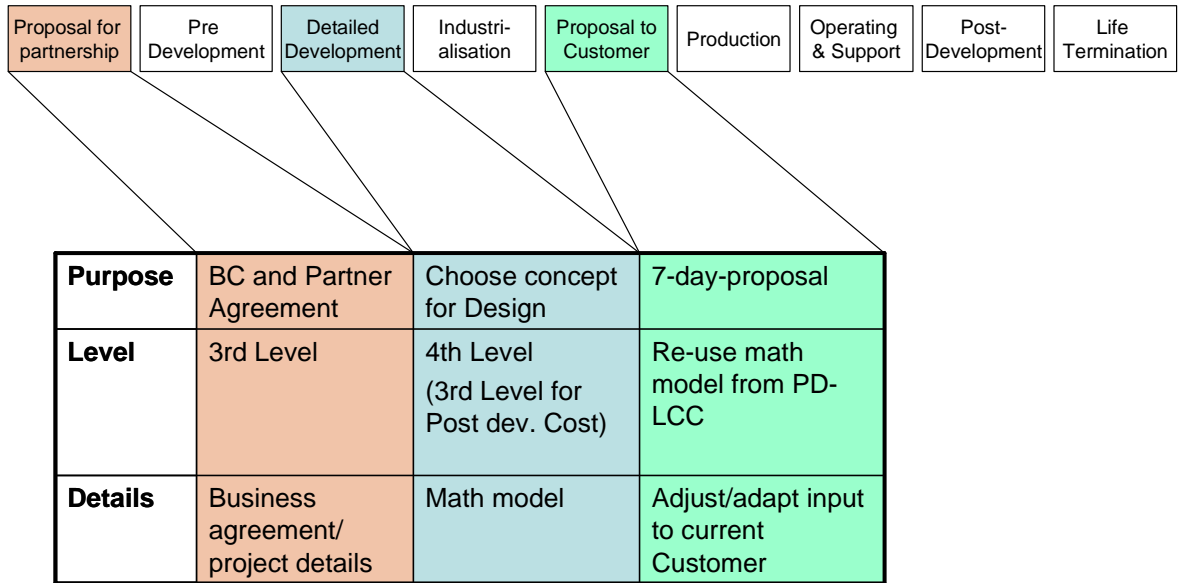
1. Individual Cost Estimation
2. Each partner creates individual Business proposal with a module breakdown structure for a total Customer proposal
3. Agreement on Module breakdown Structure & Content (by iterations 3-6)
4. Individual update of Module breakdown Structure & Content by each Partner
5. Individual update of Cost Estimation
6. Discussion on assumptions & Cost Estimation results; iterations back to §3 as many times as needed for agreement.
7. Agreement on Customer Proposal

Processes – To Be:

1. Agreement on Standardized Module breakdown Structure according to LCC model
2. Discuss & agree on specific complements and exceptions/changes
3. Individual Cost Estimation by adapting parts of LCC model
4. Discussion and Agreement on Customer Proposal

LCC Structure / Level: We assume that at least some design decisions have been accomplished during product development before you do a 7-day-proposal to Customer, and therefore you can use the 4th Level of the LCC structure that you have done in the development phase (Scenario 2) and update the data in two of the LCC phases, Operating & Support Cost and in Life Termination Cost to suit the actual customer. For example basic data as the size of the customer's fleet, need of facilities, taxes, labour costs differ from customer to customer, so for the most accurate cost modelling you have to update those cost elements.

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4.2.4. Scenario 4: Design Modifications in Post Development

Name: Design Modification in Post (certification) Development

Purpose: During an engines life cycle phase “Operating & Support” there can arise problems of different nature, which need to be attended in some way. For example if the service life of a component is less than expected, you can use LCC-modelling for determining what to do about it, if it’s more economic to repair it, to change them to new spares more often than expected or to reconstruct the component, and for this analysis you use LCC.

Processes - As Is:

1. Each partner creates individual module breakdown structure for a Modification proposal
2. Individual Cost Estimation
3. Agreement on Module breakdown Structure & Content (by iterations 3-6)
4. Individual update of Module breakdown Structure & Content by each Partner
5. Individual update of Cost Estimation for each concept for modification proposal
6. Discussion on assumptions & Cost Estimation results; iterations back to §3 as many times as needed for agreement.
7. Agreement on Modification Proposal

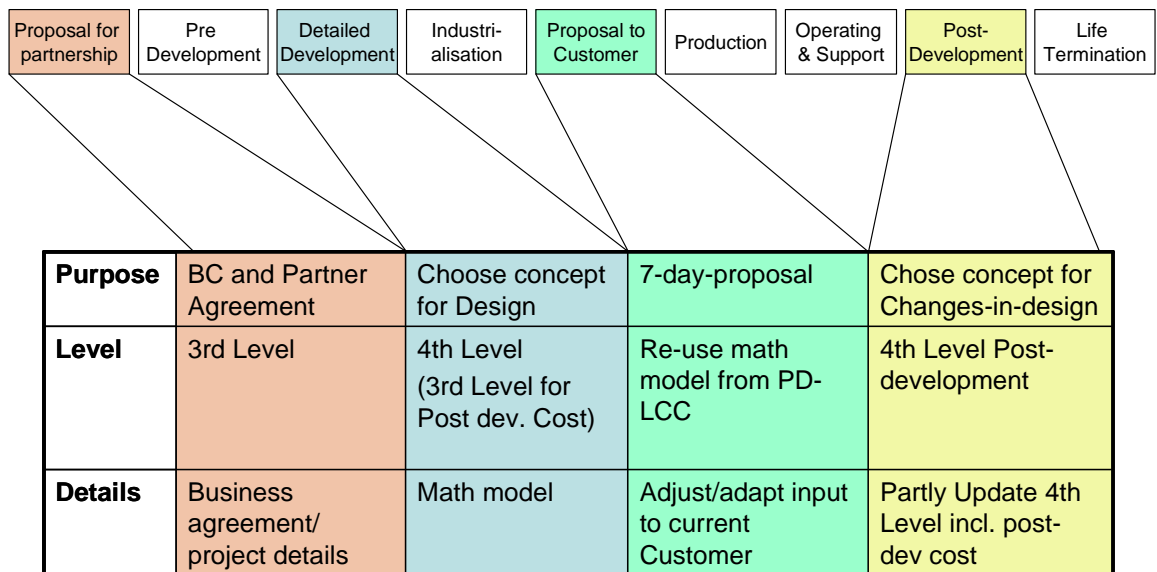
Processes – To Be:

1. Agreement on Standardized Module breakdown Structure according to LCC model
2. Discuss & agree on specific complements and exceptions/changes
3. Individual Cost Estimation by updating parts of LCC model

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4. Discussion and Agreement on Customer Proposal

LCC Structure / Level: For LCC analysis regarding design modifications, you use the Post-Development part of the Development cost, and you have to go through the rest of the LCC phases and update all cost elements that will be affected by the proposed change you are evaluating. You do this analysis with all suggested solutions to compare which of them that are the most economic to choose.



5. VIRTUAL BUSINESS SCENARIO FOR LCC SIMULATIONS IN LINE WITH ACARE

5.1. IN LINE WITH ACARE – WHAT DOES THAT MEAN?

Our Work Package is within the VIVACE part Quality & Affordability and for that part the goals and challenges are:

ACARE Goals and Challenges in Quality & Affordability:

- Fall in travel charges
- Passenger choice
- Airfreight services
- Halve supply chain time to market

Reduce cost
 Reduce time
 Ensure data traceability



The HLO (High Level Objectives) for the Quality & Affordability part of VIVACE is as shown above to Reduce Cost, Reduce Time and Ensure Data Traceability. The lead time is to be reduced by 30% and the development cost by 50%. And to these goals the standardized LCC model will contribute with reducing cost and time, mainly by shorting the work progress thanks to the standardized format, and the model will also in some way contribute to ensure data traceability by making the LCC data standardized which supports better traceability of the data.

5.2. BUSINESS CASE SCENARIO FOR VALIDATION IN LINE WITH ACARE

We have so far discussed four different scenarios for LCC analysis for a jet engine, and for the validation, as far as we can determine for now, the most suitable scenario for validation is the second LCC-scenario, where we use the LCC-analysis for decisions during product development for choosing technical solutions.

In that scenario we can use the fourth level in almost the complete LCC structure. The only part we expect not to use the level four is in Post-Development; this part will probably be estimated at second or third level this early phase of the engine life cycle. But that part is quite similar to detailed development so we don't see that as a problem. If the further work within our work package will hint otherwise in the future we have the other scenarios with us in mind so we can use any of them if necessary for the validation.

Since the goals in line with ACARE is to reduce time and cost and to ensure data traceability, we find that the validation of the model should be to show that the model contributes to these goals, and for that purpose we find the chosen scenario to be most suitable to fulfil this validation task.

6. FIGURES

FIGURE 1 THE RELATION BETWEEN THE DIFFERENT SCENARIOS AND THE LCC STRUCTURE.

Scenario 1 = Partner agreement

Scenario 2 = Chose Concept/Design in Product Development

Scenario 3 = Proposal to Customer (7-day-proposal)

Scenario 4 = Changes in Design in Post certification Development

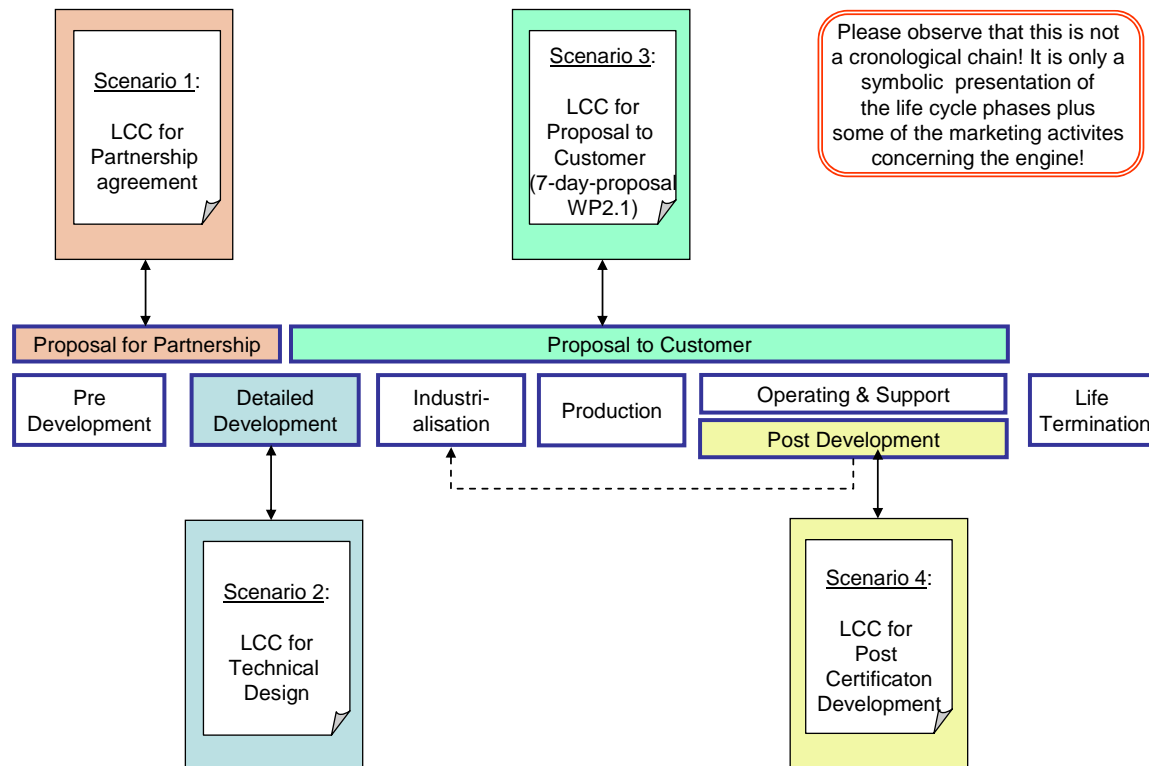


FIGURE 2 – SCENARIO 2: AS IS VERSUS TO BE

LCC - Product Development

The benefit of a common Nomenclature & Structure

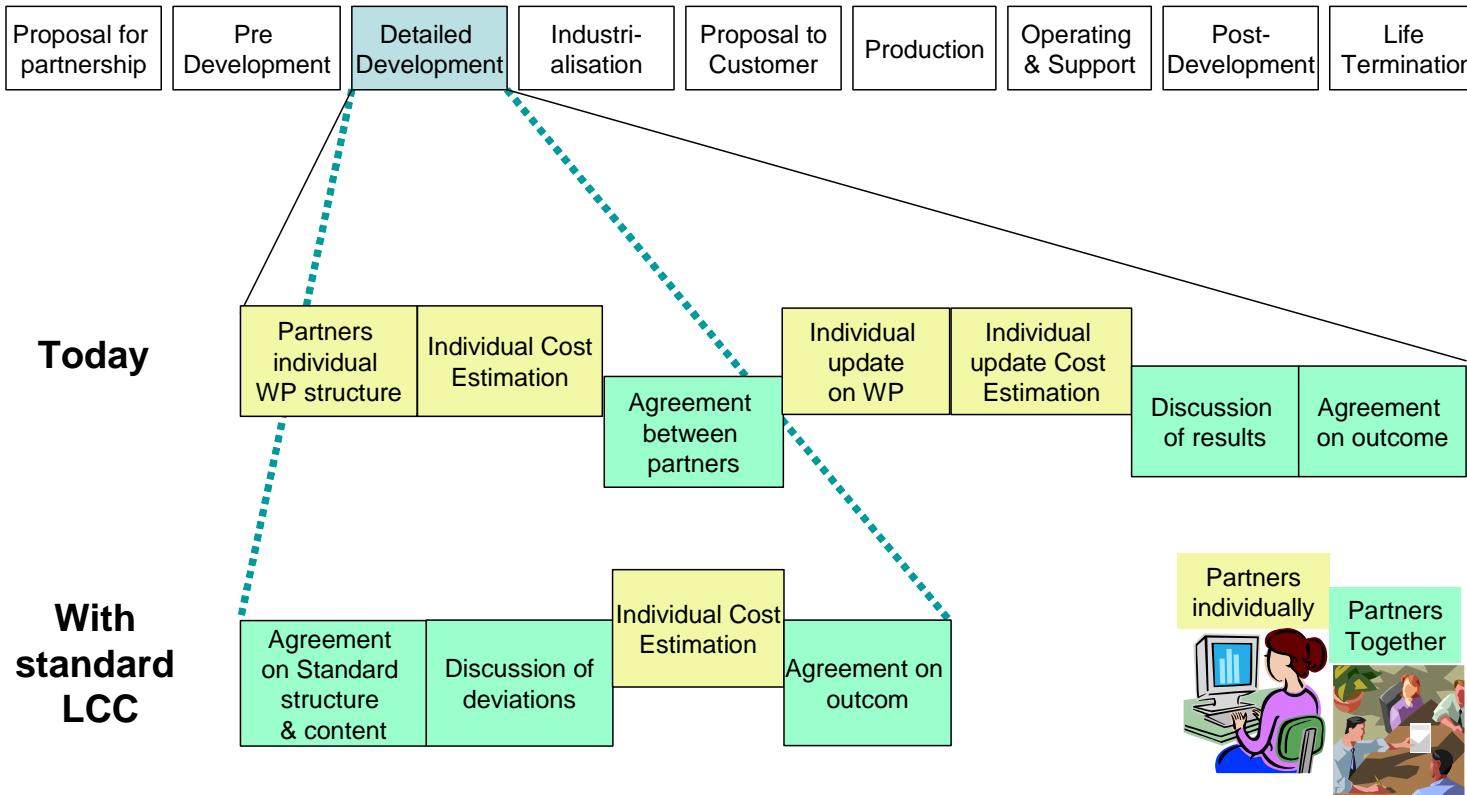


FIGURE 3 – WHICH LCC STRUCTURAL LEVEL IS USED IN DIFFERENT SCENARIOS

LCC nomenclature						
Level 1	Level 2	Level 3	Scenario 1	Scenario 2	Scenario 3	Scenario 4
Development Cost	Pre-development cost	Engineering	3-4	4	4	
		Hardware	3-4	4	4	
		Testing	3-4	4	4	
	Detailed development cost	Engineering	3-4	4	4	
		Hardware	3-4	4	4	
		Testing	3-4	4	4	
	Post-development cost	Engineering	2-3	2-3	2-3	4
		Hardware	2-3	2-3	2-3	4
		Testing	2-3	2-3	2-3	4
Industrialisation Cost		Engineering	3-4	4	4	Update 4
		Production tools	3-4	4	4	Update 4
Production Cost	Purchase and manufacturing	Purchase	3-4	4	4	Update 4
		Manufacturing	3-4	4	4	Update 4
	Programme management	Engineering support	3-4	4	4	Update 4
		Financial and commercial	3-4	4	4	Update 4
Operating and Support Cost	Initial cost	Spare investments	3-4	4	Adapt 4	Update 4

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		Ground support equipment	3-4	4	Adapt 4	Update 4
		Logistic Support Analysis	3-4	4	Adapt 4	Update 4
		Training	3-4	4	Adapt 4	Update 4
		Technical publication	3-4	4	Adapt 4	Update 4
		Facilities	3-4	4	Adapt 4	Update 4
	Recurrent cost	Maintenance Labour Cost	3	4	Adapt 4	Update 4
		Maintenance Material Cost	3	4	Adapt 4	Update 4
		Customer support	3	4	Adapt 4	Update 4
		Fuel, oil	3	4	Adapt 4	Update 4
		Operational taxes	3	4	Adapt 4	Update 4
Life Termination Cost		Administration cost	3	4	Adapt 4	Update 4
		Recycling cost	3	4	Adapt 4	Update 4
		Scrapping cost	3	4	Adapt 4	Update 4