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REPORT DETAILING VALUE CHAIN PERFORMANCE MEASUREMENT APPROACH, WITH OUTPUTS FROM VALUE CHAIN SIMULATION MODEL(S)

EXECUTIVE SUMMARY

In the aero-engine value chain several companies interact and collaborate to manufacture Original Equipment (OE - the aero-engine) that is used by airlines (operators). The operation of flight schedules leads to usage of the engine and this drives the requirement for ongoing maintenance, repair and overhaul over the life of the engine. The value chain supplies the OEM with material for both assembly into OE and aftermarket maintenance.

The decisions about the structure of this web of interacting companies is complex and dynamic and forms part of OEM's Operations and Business strategy. The problems of choosing an appropriate strategy are compounded by high risks and unusual financial performance; the value chain partners regularly accept paybacks in the region of 15 years for engine development and investment programme. The reasons for accepting this risk are outside the scope of this deliverable but are closely linked to strong competition amongst a small number of manufacturers.

The OEM has begun to use Risk and Revenue Sharing agreements as the principal method to engage with the tier 1 supply chain members.

The industry is also changing the way sales to the customers are structured. Virtual airline business models (discussed in D2.1.2_2) have driven the need for OEMs to move away from OE and consumables sales, to deals incorporating 'service' principles, accepting the risk for maintaining the engine on wing. OE can be bundled with aftermarket services to create a product, such as TotalCare™. Operators still pay for the OE (although this may be significantly discounted), and the cost of maintenance is covered through usage payments based upon engine flight hours (EFH) and engine flight cycles (EFC). Previously these costs would be incurred as maintenance bills (the traditional time & materials model) when a shop visit occurred. The OEM therefore accepts some of the risk of the airline, as revenue is linked to flying hours and cycles but this is further complicated by the discounts on OE which means that aftermarket revenues are needed to deliver overall engine programme profitability.

For the value chain, it is felt that the results of these trends are not well understood, neither in terms of impact on finance or operations. Payback periods are long and uncertain, and uncertainty regarding the future business environment acts to increase this problem. This breeds distrust that may undermine business relationships and limit collaboration between value chain partners.

Computer simulation can be used to understand how a firm or group of firms operate and interact. If a simulation can be developed to accurately represent the aero-engine business, its performance under a variety of organisational structures and

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future business environments can be explored and investigated. There is potential for knowledge to be gained about the effects of existing decisions and to inform future decision making. There is a need to capture operations and transactions in the supply chain but also a need to understand how these may lead to, or affect the behaviour of the value system as a whole. To address these two needs previous work (D2.1.1_4) has argued that the agent-based simulation methodology is a suitable choice of approach.

In an agent-based model the system is captured as a series of components or agents. These are self-contained units with specific states, behaviours and time frames. Emphasis is placed on internal processes and decision making rather than the sequence of events (the focus of other types of simulation). Agent modelling produces models that are intuitively close to the 'real world' and it is becoming more feasible and attractive with increasing computer power.

Within this deliverable, the most mature version of the model proposed initially in D2.1.1_4 is expanded. The simulation now records a broader range performance measures, and accepts greater variability on how variables and parameters can be changed by the user. This has led to an enhanced range of scenarios and experimentation that can be performed and interpreted.

The highlights of the results from the simulation study reported here are described below:

- For the benchmark case, programme breakeven is reached at 10 years for the 1st tier RRSP and 12 years for the OEM.
- The current trend for increased sales of TotalCare™ is sustainable by the industry and comparable paybacks can be demonstrated. However, in the early years it leads to lower incomes and delays the break-even point. Programme risk is therefore increased.
- These effects worsened when combined with 'Power by the hour', a very high OE discount and a high EFH rate. A 'tipping point' can be identified where, as the engine fleet requires the first major service, the income is insufficient to cover this cost. As such additional financial investment from the partners is required.
- The simulation shows that the threat of PMA is significant and the industry is highly sensitive to market capture of the aftermarket. At 50% market capture, payback is delayed beyond an acceptable timeframe and at 25% is barely achieved at all. These problems are significantly compounded if the time value of money is taken into consideration. In this model, these issues are more evident for the OEM than the 1st tier RRSP.
- The disposable engine can mitigate some of this threat, and achieves a quicker payback for the industry. However, operators need to accept paying more for the engine up-front and for the Aero-engine industry lower total paybacks are expected unless development costs and manufacturing costs can be significantly reduced.

Feedback received from the contributing companies (Volvo Aero Corporation and Rolls-Royce), internally (from colleagues at UNOTT) and VIVACE Forum 2 event is commented on and how the simulation model will evolve is also discussed.