

A MODEL TO IMPROVE AIRCRAFT AVAILABILITY IN THE MRO&U TRIAD

Johan Kaelen, (corresponding), Technical University Delft, J.W.E.N.Kaelen@tudelft.nl

Prof. dr. Sicco C. Santema, Technical University Delft, S.C.Santema@tudelft.nl

Dr. Robert Jan de Boer, University of Applied Sciences Amsterdam, rj.de.boer@hva.nl

ABSTRACT

The purpose of the research is to develop a model on achieving and improving one relevant concurrent indicator for all participants in an aircraft maintenance, repair, overhaul and update (MRO&U) triad. The triad is formed by the OEM, the maintainer and the operator. We found that availability is relevant for the utilization of aircraft and could be a good indicator for collaborative success of the MRO&U triad.

This research categorizes as a theory building research (Dul & Hak, 2008). The new theory is based on the theories on triads, alliances, transaction cost economics and the theory on performance based contracts. Based on literature from these academic fields, we have identified indicators for successful collaboration with respect to availability as outcome of the triad. The indicators are used to perform a comparative study into 'airworthiness', as this is a mechanism in the aircraft MRO&U triad that creates a collaborative outcome. Based on this comparison a preliminary model of availability in the MRO&U triad is built. This model is validated in a multiple case study.

The model developed indicates that to develop a successful collaboration a performance based collaboration agreement with availability as performance indicator has to be in place between the MRO&U triad partners in which well-defined conditions are enforced.

The model can be used to improve aircraft availability by optimizing the collaboration in the MRO&U triad. The research revealed however that the model is also applicable to improve aircraft reliability, maintainability and supportability as performance outcomes of collaboration in the MRO&U triad.

The model adds on the classic transaction cost thinking, as it adds collaborative indicators.

The practical contribution of our research is that managers and operators in the aviation MRO&U field now have a model they can use to improve aircraft availability, as a collaborative result of cooperation in the MRO&U triad.

Keywords: availability, success in triads, aviation industry, MRO&U, collaboration

Competitive paper

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LIST OF ABBREVIATIONS

DMO	Defense Materiel Organization
EASA	European Aviation Safety Agency
IPR	Intellectual Property Rights
MRO&U	Maintenance, Repair, Overhaul & Upgrade
OEM	Original Equipment Manufacturer
PBC	Performance Based Contract
RAF	Royal Air Force
RQ	Research Question
SMART	Specific, Measurable, Achievable, realistic and Timely
TCE	Transaction Cost Economics
VI	Vertical Integration

INTRODUCTION

The operational cost and quality of airline operations is related to the availability of the aircraft, as an available aircraft contributes to the business value of an airline. In the operational phase of an aircraft, maintenance is an important aspect of availability, as an aircraft in service is not available for operational service. Moreover, preventive maintenance has its effect on service and mean time between service. That could be a good strategy to increase the availability.

In practice we see that decisions on eg. preventive maintenance are not taken by one party in the operational network of an airline. It needs a decision of the parties involved, such as producer, maintainer and operator, related to the Maintenance, Repair, Overhaul and Upgrade (MRO&U) of the aircraft. We call this the MRO&U triad in the aviation industry.

The MRO&U triad is for this research defined as the industrial network of one aircraft Manufacturer (OEM), one aircraft maintainer and the aircraft operator (airline). The MRO&U triad is responsible for the performance of the MRO&U process. The performance of the MRO&U process affects aircraft safety, airworthiness, availability and maintenance costs. Availability has always been a major concern of airlines. This forces OEM's and maintainers to be more proactive in trying to reduce costs and increase availability, and is an incentive for all participants to cooperate in improving the MRO&U process with respect to availability and maintenance costs (R.J.I. Basten, 2009). Van Weele, (2005) identified communication and interaction between the operator, OEM and maintainer as a requirement in order to achieve performance. Vandenbosch and Dawar (2002) demonstrated that managing interaction activities with OEM's and maintainers is a strong source of value to operators. Traditional transaction based contracts are settling the relation between parties. Dependent triads like the MRO&U triad could work together based on collaborative goals, indicating the success of an industrial network, the triad. To realize the desired collaboration, the contract parties have to work together, based on the same goal. This requires a different form of contracting of which reaching collaborative goals is the basis (van Rhee et al., 2009). The performance outcome is not a responsibility of the contractor only. It becomes a shared responsibility of the operator, the OEM and the maintainer together (I. Ng and N. Yip, 2009). This causes a reversal in the relation between parties in the triad, they now have to work side

by side (Irene C.L. NG and Xin Ding, 2010). The changed relation in the MRO&U triad requires new types of performance based contracts.

This raises the question how collaboration in the MRO&U triad could be organized in such a way that the availability of the aircraft is maximized.

In this paper we first will discuss the research question and the research methodology that guided us during our research. Next we will show the results of our study, ending in a conceptual model that guides us in our further research. We will conclude this paper with a small discussion on the achievements up to now and roads for further research.

This work in progress paper is part of the PhD research of Johan Kaelen.

RESEARCH QUESTION AND METHOD

In our research we want to learn about collaborative goals for cooperation in industrial networks in general and for the MRO&U triads in the aviation industry in particular. We have chosen ‘availability’ as a potential driver for value of the MRO&U triad, as availability is an output indicator of the maintenance process. Availability of an aircraft is also the (input) driver in the business model of an airlines in its operations.

Therefore, our Research Question (RQ) is “How to achieve availability in the MRO&U triad”. Our aim with our research is to come up with a model that enables the improvement of availability in the Aviation MRO&U triad through an improved collaboration between involved parties.

The methodology used for finding an answer to this question is adopted from Dul and Hak’s structure for theory building and testing (Dul and Hak, 2008). The major research methods used in this work in progress paper is ‘literature study’. In future research we will use ‘Comparative case studies’ to create more input and possibly validate findings.

A literature study is performed on existing theories related to process improvement, collaboration, cost reduction and aircraft maintenance. Theories on maintenance cost reduction and improving maintenance processes are reflected in maintenance literature (Suwondo, 2007). Other theories (Value driven maintenance, integrated logistic support, six sigma, lean manufacturing, visual factory and just in time delivery) are used to analyze improvements and cost reductions (Jones, 2006, Harry and Schroeder, 2007). At the same time theories on (supply)chain management and supply chain optimization (Li, 2012) are analyzed. However, theories addressing specifically the improvement of the inter-organizational MRO&U processes are sparse (Kinnison, 2004). Achieving availability in the aviation MRO&U triad is not researched before.

LITERATURE STUDY

In our literature study we looked into the next academic fields:

- Triads
- Alliances
- Transaction cost economics

- Airworthiness

We would like to make one remark on the transaction cost economics (TCE). TCE is a popular basis for understanding and analyzing the collaboration between firms. Factors relevant for the decision making of inter firm collaboration as well as the factors relevant for governing an inter firm collaboration are derived from TCE. However TCE theory is based on inter firm collaboration between two entities, where in the MRO&U process inter firm collaboration between three independent entities takes place. Furthermore TCE uses transaction costs as the main driver for the decision between insourcing and outsourcing, while for this research the quality of the performance outcome of the inter firm collaboration is the main driver for the decision process.

Additional insights in inter firm collaboration in the MRO&U triad were derived from the assessment of the airworthiness method, which was identified to be an effective method to achieve airworthiness in the MRO&U triad. The airworthiness mechanism facilitates inter firm collaboration between the three independent entities; OEM, maintainer and operator, and it establishes the conditions to realize a performance outcome of the MRO&U process that improves over time. It is assessed that; “the airworthiness method provides a sufficient condition to achieve airworthiness in the MRO&U process by establishing inter firm collaboration between the OEM, the maintainer and the operator”.

This is an indication that the concept of the airworthiness method could be effective to manage the MRO&U process. Above ideas resulted in a preliminary conceptual model. Based on the research performed by Smets, 2008, and Rijsdijk, 2012, aircraft availability was for this research divided in its constituent parts; reliability, maintainability and supportability. For each of these constituent parts the comparison with the airworthiness concept was performed.

RESULTS

From triad, alliance and TCE theories factors of influence were identified to support inter-firm and intra-firm collaboration and to achieve a collaborative performance outcome. No theory was identified in literature that specifically addresses the achievement of a desired performance objective as outcome of the MRO&U triad. However; an existing well-functioning method to achieve airworthiness as outcome of the MRO&U triad was identified; the airworthiness method. From this method factors of influence could also be derived.

From triad literature we learned that relationships will develop between the triad partners (Dwyer, Schurr and Oh, 1987, Dyer and Singh, 1998), which affects the power balance in the triad (Wynstra et al., 2012), the exchange of information and the development of shared interest between triad partners (Tate et al., 2010). It is suggested that the shared interest will develop into a common performance objective for the triad as a whole (Peng et al. 2010) and the development of an inter-firm measurement system for performance (Neely, 2005). This development is supported by a Performance Based Contract (PBC) between the triad partners (Wynstra et al. 2012).

From alliance theory we learned that performances of alliances improve if partners coordinate their activities and information is exchanged (Anand and Mendelson, 1997). The efficiency of alliances improve if common interest are defined (Persona et al. 2007). From a literature survey performed by Sakburanapech (2008) eight key factors for alliances are identified; mutual understanding, clearly defined agreement, commitment, flexibility, organizational

linkage, performance evaluation, communication and trust. Furthermore to support alliances two mechanisms are identified; Vertical Integration (VI) for intra-firm collaboration and contracting for inter-firm collaboration (Al-kaabi et.al. 2007). For collaboration aimed on achieving a common objective, the PBC is identified to be applicable (van Rhee et al., 2009, Johnson et al., 1996; Nooteboom et al., 1997; Parkhe, 1998; Luo, 2002). From alliance simulation theory (Krainers, 2000) we learn that in the absence of a power balance between partners, collaborative behavior is not balanced and that alliances which are formed under such conditions are not stable. Down-stream vertical integration, i.e. the OEM and the maintainer are merged, leads to a power unbalance between OEM/maintainer and operator (Carpenter and Coughlan, 1999). Modern ways of communication (social media, E based interactions) are not considered in these sources.

In Transaction Cost Economics the decision between vertical integration (insourcing) and building an alliance (outsourcing) is taken on the basis of transaction cost considerations (Williamson, 1981). The focus of TCE is the assessment of different modes of coordination and the types of contracts associated for choosing the coordination mechanism which minimizes transaction costs (Williamson, 1996). This assessment is leading to the choice of the governance structure of a firm (van Meurs, 2010). The inter-firm governance structure is described by three dimensions; the information exchange, integration, and infrastructure of the collaboration (Gerybadze, 1995; Kornelius, 1999; Walters, 2002, pp. 314-342). From these dimensions De Jong (2010) derived the factors of influence for inter-firm collaboration; information exchange, a measuring and control system and a consultancy system. Furthermore De Jong (2010) identifies the need for a mechanism to establish and maintain the collaboration.

The airworthiness method offers an example of collaboration in the MRO&U triad, aimed at the achievement of a common performance objective. From analyzing the airworthiness requirements (EASA, 2013) for aircrafts, the factors of influence were identified. The aircraft airworthiness design requirements are relevant for the OEM and define aircraft airworthiness in Specific, Measurable and for the OEM Achievable and Realistic terms. An aircraft needs to be airworthy before delivering it to the operator, which introduces the factor Time. The airworthiness requirements define the aircraft airworthiness in SMART (Specific, Measurable, Achievable, Realistic en Time dependent) terms. The aircraft operations airworthiness requirements define a collaboration mechanism between OEM (which could be the aircraft OEM or a parts provider), maintainer and operator which is designed to establish, maintain and permanently improve aircraft airworthiness. The airworthiness requirements define a range of mandatory instruments to develop and support the collaboration mechanism between OEM, maintainer and operator. These instruments were analyzed to identify the factors of influence, i.e. the critical success factors, which were; A shared interest to achieve a required level of airworthiness, a communication system with respect to aircraft airworthiness, a joint performance measuring and control system on airworthiness, a penalty and consultancy system if airworthiness performance requirements are not met and a balanced force field between operator and maintainer/OEM (a level playing field).

The airworthiness method serves as an analogy for an availability method. By analyzing airworthiness and its constituent parts it was assessed that availability, as well as its constituent parts; reliability, maintainability and supportability could be expressed in SMART terms.

From the assessment of the collaboration mechanisms, identified in literature, down-stream (virtual) vertical integration (VI) and performance based contracting (PBC), it was found that down-stream vertical integration could serve as a mechanism to establish and maintain reliability and maintainability. To establish and maintain availability however, the involvement of the operator was found to be mandatory.

PBC was assessed to be suited to serve as a mechanism to establish, maintain and improve availability, reliability, maintainability and supportability in analogy with the airworthiness mechanism. Down-stream VI generates a joint interest and communication lines between the merged functionalities (design, building and maintaining). The joint interest was assessed to be related to the creation of stakeholder value and maximization of profit margins. A PBC between OEM, maintainer and operator with aircraft availability as performance objective, generates a shared interest (availability) and facilitates the development of a performance measuring and control system, as well as communication between MRO&U partners. In PBC's a penalty and/or reward system is in place as incentive for the partners to meet the performance objectives and to settle disputes without jeopardizing the collaboration a consultancy system is in place. In a PBC each of the partners is entitled to apply a penalty if a partner does not meet its performance objective, which leads to a power balance in the triad. The PBC on availability shares the critical success factors with the airworthiness mechanism, which stipulates the analogy.

The factors of influence identified in triad, alliance and TCE theories were used together with the analogy of the airworthiness model to build a conceptual model, in which the factors of influence are incorporated. This conceptual model is applicable on airworthiness as well as on availability. The conceptual model distinguishes between the properties of the triad performance objective and the collaboration mechanism. The collaboration mechanism is expressed in terms of functionalities and success factors. All three aspects; performance properties, functionalities of the mechanism and the critical success factors are relevant for the conceptual model on aircraft MRO&U triads developed through this research. The conceptual model was regarded as a MRO&U conceptual model on the achievement of availability and its constituent parts; reliability, maintainability and supportability, as outcomes of the MRO&U triad. Whereby the MRO&U conceptual model was characterized by availability (as well as reliability, maintainability and supportability) defined as performance outcome in SMART terms, and by a mechanism that establishes, maintains and improves availability (as well as reliability, maintainability and supportability) as outcome, and complies with the critical success factors;

- A shared interest between chain partners to realize the performance objective;
- A clearly defined communication system between chain partners;
- A measuring and control mechanism for the performance outcome of the chain;
- A consultation and penalty system;
- A level playing field.

The conceptual model is reflected in fig 1.

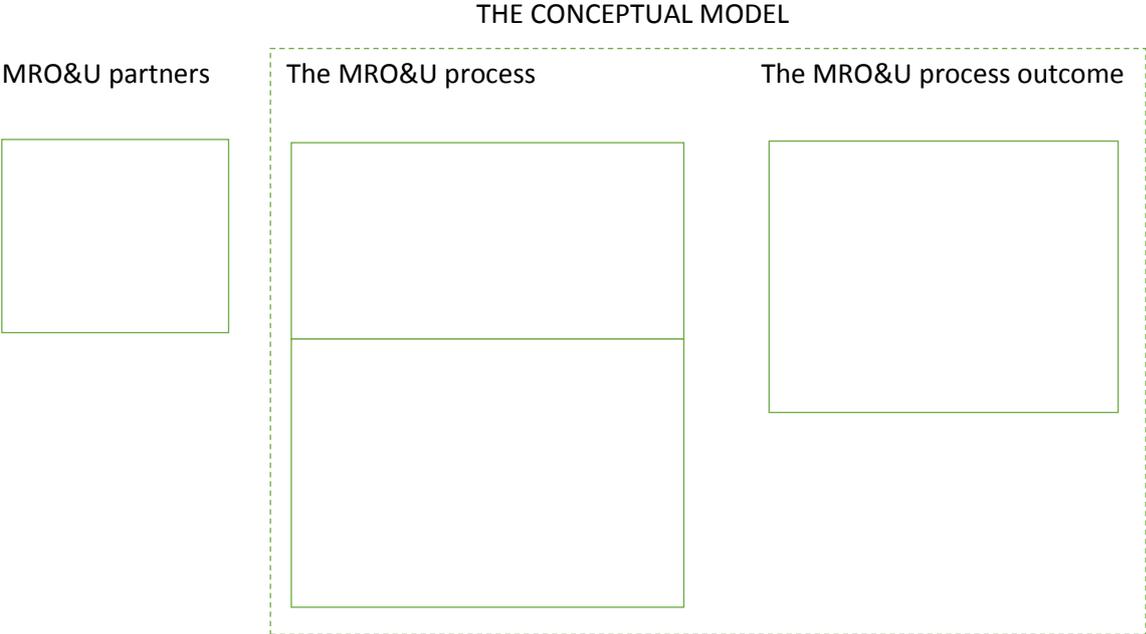


Fig. 1. The conceptual model

Validation of the conceptual model using a cross case study indicate the validity of the model, but the number of cases was insufficient to be statistically significant.

DISCUSSION

The research revealed that literature on triads, alliances and Transaction Cost Economics provide insight in the conditions, features and the factors of influence of inter-firm collaboration, but does not specifically address the collaboration in the aircraft MRO&U triad. The aircraft airworthiness method was assumed to be an example of a successful collaboration in the MRO&U triad and was used as analogy to develop a method to achieve aircraft availability. Based on this research approach a conceptual model for achieving availability as performance outcome of the MRO&U triad was developed, with availability defined in SMART terms and with PBC as mechanism to establish, maintain and improve availability and to comply with the critical success factors. As assessed in this research the PBC could be used as an analogy of the airworthiness mechanism. However to establish a well-functioning PBC shows to be a difficult and long-lasting process (DMO Discussion Paper, 2009). The changed relation between partners and the development of a comprehensive set of conditions are obstacles. The majority of PBC's is not successful, either because the performance is not met, or because the relation between principal and contractor brakes up (classic TCE effect). An important reason is that performance is difficult to define in SMART terms and is hard to measure (Baker, Gibbons and Murphy, 1993). It was assumed that a PBC that complies with all the factors of influence from the conceptual model (see fig. 1) offers a sufficient condition to successfully achieve the desired performance outcome of the MRO&U triad. Confirmation of this assumption however requires further research.

Applicability of the model

The research revealed that the preliminary conceptual model was applicable on availability as performance outcome of the MRO&U triad. As has been shown by Smets, 2008, and Rijdsdijk, 2012, the model was also applicable to each of the constituent parts of availability; reliability, maintainability and supportability, each being a performance outcome of the MRO&U triad.

The model was based on an analysis of the method with which airworthiness is achieved as performance outcome of the MRO&U triad. Consequently the model was applicable to airworthiness as a performance outcome of the MRO&U triad as well.

The model proved to be applicable to a broad range of performance outcomes of the MRO&U triad. The MRO&U triad consists of three independent entities, the OEM, the maintainer and the operator. In more general terms; the supplier, the service provider and the buyer. A triad consisting of these three independent entities is a common phenomenon and can be found in the automotive sector, the infrastructure sector, the machine building sector, the IT business etc. In these cases each of the entities contribute to the performance of the “product” and are in the position to improve the performance of the product. In that respect these triads are similar to the MRO&U triad.

It is assumed that the model could also be applicable on these triads, which would make the model a general model on the achievement of a desired performance outcome of a triad consisting of a supplier, a service provider and a buyer.

Based on these insights it was assumed that the model could be applicable to all performance outcomes of the MRO&U triad, as well as other kind of triads. However this assumption needs further research to validate and confirm.

The triad, alliance and TCE theories

Triad theory in literature is about the collaboration between two buyers and a supplier or two suppliers and one buyer (Wynstra et al. 2012). The MRO&U triad is about the collaboration between operator, maintainer and OEM, in general terms buyer, service provider and supplier. According to Wynstra et al. 2012 triad collaboration is established with as driving factor the achievement of a performance outcome. From a literature survey, he concludes that research on triads on the basis of performance based contracts is sparse.

In this research for the first time a study was made of the collaboration between three different entities. This research provides an unique insight in the mechanism, features and conditions of a successful performance based contract, as well as the relevance of these characteristics for the success of the collaboration in the triad in terms of a desired performance outcome and contribute to the enrichment of the triad theory. Furthermore the theory developed under this research provides an indication on how an alliance between three independent entities can be successful with respect to a desired performance outcome. As such this research contributes to the extension of the alliance theory.

According the transaction cost economics theory (TCE), outsourcing and collaboration are based on the cost criterion. If the transaction cost of outsourcing are lower than the transaction cost of insourcing, a decision for outsourcing is taken. TCE is extensively studied and applied

in practice. It has developed into an advanced theory, which is commonly accepted especially for governing transactions (Shelanski and Klein, 1995).

This research was aimed at achieving availability as outcome of the MRO&U triad. Availability is a performance outcome of the collaboration in the triad. The main driver for collaboration was in this research found to be the optimized realization of the performance outcome, even if the transaction costs were higher.

Under this research a theory was developed that provides insight in the factors relevant to manage collaboration and to jointly realize a desired performance outcome. The new theory is applicable on collaboration on the basis of a performance based contract and is an extension of the existing TCE theory and could replace that theory in the cases where achieving performance optimization is more important than costs optimization. This new theory could be regarded as a “transaction performance theory”.

The triad and down-stream vertical integration

Literature (Kraines et al., 2000) suggests a relation between the stability of an alliance and the presence of a level playing field. Subject are alliances between two independent entities. If these entities have comparative power positions a stable alliance is possible. If not, the alliance tends to become unstable, whereby external pressure on the alliance accelerates this process.

In practice in aircraft MRO&U several unbalanced alliances are in place between an operator and a vertically integrated OEM/maintainer (I. Ng and N. Yip, 2009). Examples are; Boeing “GoldCare” (OEM/maintainer) and Norwegian Air shuttle (operator), Lockheed Martin “contracting for availability” (OEM/maintainer) and the US Air Force (operator), Rolls Royce “power by the hour” (OEM/maintainer) and the RAF (operator). These alliances are relatively new and based on a PBC, which may affect the stability of the alliance. It is still too early to assess whether these alliances are stable in the longer term. Further future research is required to assess the stability of these alliances.

In literature no studies could be identified which assess the stability of MRO&U alliances between down-stream vertically integrated OEM/maintainers and operators or between up-stream vertically integrated operators/maintainers and OEM’s. Further research is required to assess the stability of an alliance and vertical integration, whether down-stream or up-stream.

The position of the maintainer

The use of a PBC in the MRO&U triad levels power position between operator and OEM respectively the maintainer. If the OEM of maintainer are not performing as agreed, a penalty is due, or payments are postponed by the operator. This counter balances the power of the OEM which possesses the Intellectual Property Rights (IPR) of the aircraft as well as all the data relevant for the performance of the aircraft. The operator is also in the position to postpone payments or apply penalties to the maintainer if performances are not met. However the maintainer is not in the position to apply power on the OEM or on the operator. As a consequence the maintainer is in a weak position in a triad where a PBC is applied.

This might be the reason why PBC on aircraft availability are always issued by Down-stream VI OEM/maintainer combinations, and that these combinations tend to increase their market

share, where independent maintainers loose field. Based on this trend it is expected that with the wider spread of PBC's in aircraft maintenance, the market share of independent maintainers will further decrease, while more down-stream VI OEM/maintainers will enter the market. The independent maintainers will be taken over by OEM's, or become subcontractor of an OEM.

Another consequence of this trend will be that the OEM's who offers the best "total package" will attract more customers (operators) and will gain market share. Such a "total package" will be aimed at optimization of the Life Cycle Cost for the operator. Boeing's GoldCare program is good example of such a total package. For the operator the availability of their aircraft, and thus their profitability, will become more and more dependent on the performance of these "total package" programs.

For some operators, like some air forces, this dependency is not eligible. This has led to up-stream vertical integration, where operators are integrated with maintainers and perform their own aircraft maintenance. To get access to the IPR required to maintain the own aircraft, the transfer of IPR from OEM to operator/maintainer has to be a contract condition when the operator is purchasing new aircraft.

Practical application of the model

The conceptual model developed in this research is applicable for practical situations where collaboration on the basis of performance based contracts is in place. The conceptual model represents an overview of all factors relevant to develop a successful collaboration between two or three independent entities. As such the model could be used as a checklist to identify whether all relevant conditions are met.

This could be relevant for performance based contracts in place or offered by down-stream Vertically Integrated OEM/Maintainer organization with respect to aircraft availability, like the Boeing GoldCare program, the Rolls-Royce power by the hour program etc.

Firms or organizations that intent to start a collaboration with the aim to realize a desired performance outcome, could use the conceptual model to assess the maturity of the collaboration agreement.

For aircraft operators the conceptual model offer a means to develop or validate service and supply performance agreements. The application of the conceptual model improves aircraft availability and has the potential to increase the turn-over for airlines.

Furthermore the conceptual model is relevant for governmental organizations which are in the process or have the intent to outsource public services to private companies. The conceptual model could be used as a guideline for developing the collaborations and issuing the performance contracts. Using the conceptual model improves the chances on a successful and long lasting collaboration and on better performance outcomes.

FURTHER RESEARCH

Obviously, the result presented in this competitive paper have to be researched further. We are now looking for partners in the MRO&U Dyad that are willing to deliver cases in which

they cooperate with the others in the Dyad. We opt to build a theory on MRO&U Dyads in the aviation industry. Along the lines of Dul and Hak (2008) we want to test the conceptual model (see figure 1) and validate the assumption made from other theories in the literature research. After we have done so, we would like to extend our research into other industries.

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