A Conceptual Model of Supply Chain Coordination in Aerospace Industry

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Abstract Global supply chain of aerospace industry is a typical system that needs coordination. The paper starts with a brief description of the structure of the supply chain in Aerospace industry. Next, makes the supply chain flow analysis by the means of SCOR. Finally, this paper constructs a coordination conceptual model in the supply chain of aerospace manufacturing industry which is actually a design frame of coordinative supply chain.

Key words Supply Chain, Coordination, Conceptual Model

1 Introduction

In table 1, it shows the academic research issues and fields involved in supply chain coordination by us.

| Coordination on strategic lever | Coordination on tactic and operational level[^1]
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<tbody>
<tr>
<td>-Coordination issues in SC partnership;</td>
<td>-General Coordination</td>
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<td>-Coordination issues in Partners selection &amp; evaluation;</td>
<td>-Multi-Plant Coordination</td>
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<td>-Design of incentive &amp; supervision mechanism in SC operation;</td>
<td>-Buyer-Vendor Coordination;</td>
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<td>-Negotiation mechanism in SC operation;</td>
<td>-Production-Distribution Coordination;</td>
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<tr>
<td>-Coordination of risks, costs &amp; trust in SC operation;</td>
<td>-Production-Inventory Coordination;</td>
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<td>-Inter-organizational concurrent in SC operation[^9];</td>
<td>-Inventory-Distribution Coordination[^5];</td>
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<td>-Object coordination in SC operation;</td>
<td>-Order coordination(e.g., order optimization, common replenishment epochs, quantity decision in one lot, replenishment lead time);</td>
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<td>-Benefit coordination &amp; assignment in SC;</td>
<td>-Joint pricing coordination (e.g. Quantity discount policy);</td>
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<td>-Internet-enabled market mechanism &amp; coordination flow[^10];</td>
<td>-Distribution system coordination(e.g.: distribution lot, distribution plan, dynamic coordination of relations promise among distribution channels, transport routine, transport arrangement);</td>
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<td>-Coordination &amp; integration mechanism of logistics in SC network structure;</td>
<td>-Production plan coordination;</td>
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<td>-Coordination mechanism in lean SC system;</td>
<td>-Production lot coordination;</td>
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<tr>
<td>-Coordination mechanism in virtual SC system</td>
<td>-Inventory control &amp; coordination[^6];</td>
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</table>

Most of the literatures focus on coordination issues in supply chain from an operational or tactic sense. How to integrate the mechanisms and methods of coordination from a macro or holistic sense has been rarely discussed. The static operation reference based on best practice can not support the new intra- & inter-enterprise collaboration. It is necessary to develop a systematic methodology to help enterprises to define their requirements, to analyze the target system, to structure the coordination system and to monitor its operating performance.

This paper try to set up a conceptual model based on several coordination mechanisms so as to have a better understanding to inter-organizational coordination within a holistic supply chain network.
from the view of an industry. Aerospace industry is to be chosen as an example because of its complexity and its intrinsic requirement to coordination.

Coordination Mechanism in supply chain is a combination of rules and methods which the players in a supply chain abide by and use. Simatupang & Wright divided coordination mechanism of supply chain into 4 kinds [6]: Logistics Synchronization, Information Sharing, Incentive Alignment and Collective Learning. Except the mechanisms forwarded by Simatupang & Wright, some of the academic papers in China discussed the following coordination mechanisms of supply chain separately: (1) Cooperation Mechanism: it emphasis on strategic partnership as well as integration and optimal utilization of internal and external resources. (2) Decision Mechanism: it focus on the decision in the open environment based on Internet/Intranet. (3) Encourage Mechanism: it regards more on enterprise evaluation and incentive system which give us clear knowledge in which aspect and on which degree to impulse enterprise’s improvement. (4) Benchmarking: this mechanism demand the enterprises in supply chain to set the leading enterprises or the most competitive opponent as benchmark so as to decrease the gap between partners in supply chain.

2 Analysis on Supply chain in Aerospace industry

An aerospace manufacturing supply chain has some unique features that make it different from other supply chains. First is the nature of its products. The lifecycle of civil or military aircraft are more than 20 years, e.g. Boeing 747, F5E, etc. Compared with the ground equipment, aircraft parts should have higher precision and lightweight to achieve the requirements of safety, payload, and controllability. There are thousands of various parts and components. But the required quantity of specific part and component is not so high, say just several hundred.

Take reference of Chikong Huang [7], the structure of supply chain for aerospace industry can be divided into 3 layers:

(1) 1st -tier: It is also called prime aerospace contractors or OEM, including Boeing, Lockheed Martin, Airbus, Bell Helicopter, Pratt & Whitney, GE and etc., who supply civil/military aircraft or engine to airliners or customers. Companies in this tier are gigantic multi-national enterprises in aerospace industry.

(2) 2nd -tier: They supply the components, aero-structures, subsystems or avionics to the 1st - tier company. In this tier, there are AlliedSignal, Astronautics Corporation of America, Rockwell International, Canadian Marconi, Dell Computers, Inc-MRC Bearing, Sundstrand Aerospace and so on. Companies in this tier are generally large or medium professional enterprises.

(3) 3rd – tier: They supply the standard parts, detail parts or raw material to 2nd - tier company. The manufacturers of parts are mainly small and medium enterprises. However, the material suppliers are large or hyper enterprises. They possibly provide products to the supply chains in different industry simultaneously.

SCOR (Supply Chain Operation Reference) [8] developed by Supply Chain Council guides member enterprises to adjust their business processes and adapt the multiplex new system. Here, we use SCOR as a tool to describe the complex supply chain such like that in aerospace sector. The supply chain of aerospace sector is up-built on 4 essential elements in process: plan, purchase (buy) or outsource, manufacture (make) and deliver (Shown in Figure 1).

![Figure 1 Essential elements in SC process for aerospace sector](image-url)
From Figure 1, we can see that the supply chain coordination broadly distribute crosswise in plan-buy-make-deliver process among all the partners. Only the integration of one more of the selected coordination methods and functions can improve the holistic efficiency of the supply chain.

3 Conceptual Coordination Model
As shown in Figure 2, the framework of the model consists of 4 layers.

(1) Fundamental mechanism layer: In this layer, the supply chain coordination within aerospace industry is based on 4 fundamental mechanisms: Information Share Mechanism, Contract & Incentive Mechanism, Collaboration & Trust Mechanism and Collective Learning Mechanism. Collaboration & Trust Mechanism is a management approach on relationship-oriented levers. The other 3 mechanisms are on action-oriented levers.

Usually, to align goals and incentives in supply chain, contract and agreement is one way. Contract can insure the operation’s optimization of supply chain by stipulate clauses of specification of decision right, pricing, minimum purchase requirements, quantity flexibility, buyback or return policies, allocation rules, quality, lead time and etc. In many contract, there are different incentive clauses in different tiers of supply chain, such as purchasing discount, quantity discount, revenue sharing, markdown, price protect, even information share. But, we need to take notice of some unexpected accident which contract is difficult to handle and settle down. At this circumstance, other coordination mechanism is inevitable.

Information share is the core of the Coordination in technology. From production information, supply chain information, to design information, key data and information can be shared among partner enterprises within the whole supply chain. VMI, JMI, CRP, CPFR, AFR, FMS and many other
management systems closely rely on information share mechanism.

Information sharing is a challenging task that requires a high degree of trust among supply chain partners [9]. Trust issues are normally in relation to promises, safety and quality requirements, and sharing information regarding design, inventory, delivery and so on. Collaboration is often defined as two or more firms working together to create a competitive advantages through making joint decisions and sharing benefits and risks [10]. The object of Collaboration & Trust Mechanism is to establish relations based on cooperation and trust.

Collective Learning Mechanism helps to execute the benchmarking policy. It also can coordinate the industry knowledge, technical standard, multi-enterprise culture and etc.

(2) Management Layer: This is an operation layer. The supply chain coordination management aims on better behave on T (Time), Q (Quality), C (Cost), S (Service) and F (Flexibility). At this layer, the coordination includes buyer-vendor or distribution coordination, inventory coordination, transport coordination, production coordination and the coordination between or among them.

(3) Decision Target Layer: Along with the development of Internet/Intranet and its enhancement to enterprise decision support, the mode of decision for the partners in supply chain is now turned to be colony decision mode which is found on an open information environment.

(4) Enterprise Internal Coordination Mechanism Layer: It involves all the coordination relative affaires and methods within an enterprise, such as enterprise culture, inner inflict management, organization restructuring, process reengineering, and etc.

There’s a trend in the world that many of the core enterprise in the aerospace manufacturing supply chain now extend their business to be an integrator and service provider who make the system integration and information technology service as their high-speed developed business. B2B markets through collaborative linkages with trading partners, providing streamlined ordering capability and relevant business services, to enable business process efficiencies in all aspects of enterprise and inter-enterprise activities. All these will make the above-mentioned model exercisable.

The B2B markets such as Avexus, Myboeingfleet, Exostar, Aeroxchange, and Partsbase in aerospace industry now deal with enterprise product and information flow, stakeholder and organization issues as well as process and program management. Develop a trustful environment is a crucial component of B2B markets and clearly reinforces the concept of relationships based on mutual trust. Based on HTML, WAP and XML, many B2B markets furnish a flexible environment for multiple integration (as shown in Figure 3).

![Figure 2 B2B markets furnish environment for integration](image-url)
4 Conclusion
The supply chain coordination in aerospace sector is a complex systematic project. Conceptual Coordination model can help us to analyze the situation comprehensively from a relative holistic and macro view. Based on the model, the to-be inter-enterprise business logic can be designed with the supporting information system. This paper only presents a framework to model and analyze inter-enterprise coordination in supply chain. However, how to integrate all the coordination mechanisms and coordinating activities together is still a topic needed further research.

References