# SERVICE THINKING STYLES IN THE SUSTAINMENT OF AERONAUTICAL PRODUCT

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## Abstract

*Outcome-base contracts that provide through-life sustainment solutions for complex systems such as aeronautical product offer "value in use" to the customer. Service is an inherent feature of the sustainment solution where the ultimate objective is to support the client, not just the product. Service satisfaction resides in the mind of the customer and the delivery of fit-for-purpose goods is a necessary but not sufficient condition for satisfaction. The end state of service is an intangible mental concept and service satisfaction is heavily shaped by the context in which the service is received. That context includes the emotional state of mind, its perceptions and preferences, its memories and patterns of unattended automated processing, and its plans for the future. Service satisfaction requires the service provider to have a highly developed concept of the mind of the customer. The desired end state of service provision is trust, wherein the customer seeks repetition of the service.*

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## 1 Introduction

Through-life sustainment of fleets, assets and infrastructure, unless very carefully planned, can be needlessly expensive. The drive to reduce lifecycle costs of expensive assets, fleets and infrastructure has resulted in contractors assuming substantial business risk in the sustainment of those systems. In some cases, public bodies seek to transfer risk in both acquisition and sustainment to the private sector through the use of public-private partnerships (PPPs) and privately financed initiatives (PFIs). In the information technology (IT) sector, corporations are striving to achieve a mix of product and service offerings to build their order books and develop long term business streams.

Services now drive the national economies of developed countries and have done so for many decades. The growth of the services sector has been observed but largely unremarked, and many institutions have continued operating under the tacit assumption that economies are manufacturing-driven (technology-driven). Technology developments are based on reductionism, the hallmark of science, and are integrated into deliverable products through system engineering. Service provision is likewise an integrative activity, combining widely-varying capabilities. Service outputs are usually non-material and valued differently to goods, and non-cognitive factors are often very important to the valuation.

There is a sense that we now live in a post-technological age, that technology will no longer be the defining feature of our future. Technology, and the products derived from it, will of course remain deeply embedded. Sustainment, or a restatement of it, is likely to be the new paradigm for our thinking. The idea of sustainment makes sense only if the paradigm includes both the natural and built environments as seamlessly connected, coupled through society and economics. In this paradigm, technology will be truly a servant to society. It has always been so, but it was for a time granted celebrity status and regarded in isolation, disconnected from real value.

Technology, alienated by its increasingly arcane existence as scientific knowledge inexorably deepens, is marginalized when seeking solutions to today's multi-disciplinary sustainment problems. System engineering, as a set of principles and processes, is well established to guide the integration of complex technical systems, but is limited in its capacity to develop solutions that have powerful non-cognitive elements in the user environment.

This paper explores sustainment solutions based on complex aeronautical systems at the centre of a deliverable capability and a number of examples are provided. These systems are typically large in scale, multi-disciplinary, often exhibit emergent behaviours and are very costly to sustain.

## 2 Contracting for Outcomes

The UK Ministry of Defence (MoD) has defined a hierarchy of four levels of sustainment contracting as follows:

- Provision of spares and repairs – the traditional sustainment approach
- Integrated logistics support packages – for example, performance-based logistics
- Availability contracting – for example, contracting for available aircraft daily on the flight line
- Capability contracting – for example, provision of an operational mission capability

This list is in order of increasing complexity and increasing risk transfer to the contractor. Contracting for availability and contracting for capability lie within the class of outcome-based contracts as described in [1]. From the point of view of sustainment, contracting for availability often places the sustainment of assets at the forefront, while in contracting for capability the sustainment solution is embedded within a broader service solution. A number of examples of outcome-based contracts are provided in the next section. Features of similar contracts have been examined in References [2] – [5].

### 2.1 Aircraft Through-Life Management: An Availability Contract

Through-life management of the UK Royal Air Force (RAF) fast jet fleet of 220 Tornado aircraft has required the development of a large scale sustainment solution for the UK Ministry of Defence. There are two contracts in this program, one for support of the airframe, and another for the engines [6]. The combined contract value is almost £2 b over a ten year period. The airframe contract is known as Availability Transformation: Tornado Aircraft Contract (ATTAC).

Following the end of the cold war, the MoD was presented with an opportunity to rationalize its support footprint for the fleet, and to transform its business approach by outsourcing support. In contrast with traditional spares and repairs contracts, these arrangements contract for availability. Aircraft availability is defined as aircraft provided to the flight line in an agreed configuration, with the required maintenance completed to the required quality, on schedule and to cost, available for a given flying task. This requires the contractor to engage in fleet management, something previously limited only to military personnel; it also requires the contractor to think more like the customer, to understand the military operational domain. Availability contracts incentivize contractor performance (and penalize underperformance), so that, like the customer, it seeks to effectively manage costs in the logistics supply chain on behalf of the customer (a feature of a service culture).

In this contract, engineering is just one workstream amongst eight (there is an upgrade component to the contract, as well as maintenance engineering). This is in contrast with system creation, at the start of the product lifecycle, where engineering is the dominant activity and system thinking is the dominant thinking style. To date, the cost of support has decreased significantly, with a significant reduction in cost for each flying hour.

### 2.2 Coastwatch Aerial Surveillance: A Capability Contract

The Australian Customs Service through its Coastwatch operation [7] provides air and marine based civil surveillance and response services to detect and monitor, report and respond to intrusions into Australian coastal regions. It contracts the aerial surveillance task to industry, requiring an annual flying effort of 20,000 hours per year. It is believed to be the world's largest aerial civil maritime surveillance operation, operating from four bases in northern Australia. The contracted aerial assets include fixed and rotary wing aircraft, all owned, operated and supported by the contractor. These aerial assets work closely with civil and military authorities to detect illegal drug smuggling, people smugglers and illegal fishing.

Flights may range up to 900 nautical miles off shore. Tasking encompasses the detection, classification and tracking of:

- Illegal traffic and fishing
- Illegal immigration
- Quarantine threats
- Smuggling operations

The larger fixed wing and rotary wing assets in the surveillance fleet are equipped with a tactical data system to manage the tasking and the large quantities of data collected from the on-aircraft sensors. This is done through two elements, one for mission planning, monitoring and evaluation of the tasking, the other for managing the data, using tactical data and communication satellite links. A National Surveillance Centre (NSC) provides a current surface picture of the monitored region that can be made available to other agencies, including defence agencies. Tasking prior to missions is uploaded from the NSC.

As Coastwatch contracts for a surveillance capability it would be classified as a capability contract.

## 2.3 Aircraft Engine Availability Contracts

The UK RAF aircraft availability contract described above incorporates a separate engine availability contract - RB199 Operational Contract for Engine Transformation (ROCET) [6]. The contractor takes full responsibility for sustainment of the engines and guarantees availability of engines at an agreed level and assumes the risk of engine malfunctions. This in turn provides certainty of costs for the operator. Under the terms of this contract, the prime contractor is accountable for all repair and overhaul activity, including full responsibility for spares provisioning, inventory management, and technical and logistics support to the end customer.

Contracting for availability of aircraft engines is also practiced in some instances in the airline industry. Customers can elect to contract for a sustainment package on the basis of availability at a defined cost per flying hour. It could cover, for example, scheduled and unscheduled maintenance, unit exchange for line replaceable units, life-limited part replacement, spare parts replenishment and incorporation of Service Bulletins, all tailored for the specific needs of the customer. In this scenario, the customer does not need to manage the aero engine supply chain and is able to better focus on the core business of transporting passengers.

## 2.4 Military Flying Training Contracts

A number of western air forces now contract elements of flying training to contractors using outcome-based contracts. Two examples exhibiting quite different features are briefly described below. One is a complete turnkey operation for basic flying training using civilian instructors; the other is a contract to provide a fleet of training aircraft (including a military jet type) which are used by military instructors to train in accordance with relevant military practices.

### 2.4.1 Provision of Basic Military Flying Training

In this example of a capability contract, the Australian Defence Force has outsourced its basic flying training for its three armed services. In this contract, the operational fleet of basic training aircraft is owned, maintained and operated by the contractor. The aircraft are operated on the civil register. The contract has two major components:

- Flight screening program for candidate student military pilots
- Basic flying training for student military pilots

The choice of aircraft type is left to the contractor in this contract for capability. Within reasonable limits, the customer is not interested in the type of aircraft selected by the contractor, as long as the service requirements (flight training) are met. The contractor is required to provide a specified number of aircraft on the flight line in accordance with the daily training requirements. The contract is executed at a civilian airport using civil infrastructure.

The customer places additional contractual requirements on the contractor, including:

- Operation of an approved flying school to civil standards
- Operation of an approved aircraft maintenance organisation, to civil standards
- Management of student cohorts
- Facilities management, including accommodation and catering
- Ground support services for flying operations

Sustainment of the fleet of training aircraft, while critical to the provision of capability, is largely in the background. The customer merely requires that the contractor maintain the fleet in compliance with civil standards. The fleet provides "value-in-use" but is not the central focus of the contract; the training capability is at the core.

The fleet of training aircraft and the associated maintenance, training and ground infrastructures are all owned by the contractor. Because of these features the contract may also be classified as a PFI contract where the balance sheet risk has been transferred off the customer's books.

### 2.4.2 Contract for Military Flying Training Support

The Canadian Department of National Defence (DND), seeking to reduce overall costs, sought to transfer organic support services to industry where it made business sense to do so. Ultimately, the NATO Flying Training Canada (NFTC) program was established where much of the capability for flying training (but not the actual flying instruction) was contracted to industry. A prime contractor was tasked in a 20 year contract to lead a team of major suppliers to provide the training aircraft and simulators, associated maintenance services, training material, airfield and infrastructure support services.

While the major contract is let by the Canadian DND, the training capability is available to other nations and several have used that capability to date. There are various training paths depending on the user need and customer forces use their own military instructors.

## 3 Service Concepts

A common feature of the outcomes-based contracts, examples of which are provided above, is the integration of significant service elements enabled by complex product systems. These integrated products and services to meet a customer need in service are sometimes called "product service systems" (PSS). The idea of PSS offerings as integrated systems, as well as the product component, lends itself to a system engineering approach, yet service delivery is very different in nature to product. Products are developed using the processes of system engineering. Service thinking is a distinct style from system thinking and although the two styles may be "harmonised" in the act of service delivery, they cannot be "integrated" in the accustomed sense of system engineering.

An increasing number of manufacturing companies now derive a significant portion of their revenue from service delivery and many now attribute more than 50% of revenues to services (although there is a sense that services have always been important but unacknowledged). The IT sector has been amongst the leaders in making the transition from product to product-service. The shift is also occurring in other industry sectors such as defence, mining and infrastructure, often driven by different market pressures and sometimes using a different terminology. Some of the terms used to describe the trend away from pure product include:

- capturing the aftermarket
- going downstream
- servitization
- service dominant offerings
- product-service systems
- integrated solutions
- sustainment solutions
- service and support
- through life support or through life management
- new manufacturing

All of these terms capture the idea of the provision of additional services based on a product offering. In most cases, but not all, the product is produced by the service provider. Clearly, holding intellectual property rights or design authority for the product puts the enterprise in a dominant position to support the product in service. When originally coined in the 1990's, the term "product-service system" was used to describe the strategy of product manufacturers to expand business opportunities [8], but the idea of product-service systems can be used in a wider sense (as it is in this paper) where a contractor may build services based on products from a different company. In three of the five preceding examples the prime contractor company does not hold design authority for the products on which the service is based. The term is also used to capture the idea that the PSS is designed to support the customer, not merely the product, an important distinction.

### 3.1 Service in the Information Technology (IT) Sector

The IT industry sector has proposed the development of "service science" for IT-enabled services. Service as a science may seem unusual to those steeped in technology and product development, but service is certainly amenable to systematic analysis and evaluation. Service has a characteristic cognitive style – service thinking – that can be contrasted with the system thinking style.

Service is the essence of the economic existence of all developed economies and arguably merits rigorous intellectual attention. The information technology industry has been the business leader in seeking to establish services on a sound academic footing, promoting the idea of service science. Many IT companies now derive more than half of their revenues from service provision, driving the transformation of their enterprise business models from developer of technology products to provider of technology services. These services are often based on their own products, but may also include products from other companies. The service focus may encompass inventory management, supply chain management, purchasing, financial processing, people resource management, in fact any business process that requires significant data management. In servicing the enterprise needs of its customers, these newly transformed service companies develop a sophisticated understanding of business processes that can be further employed to enhance their technical products, locking in future service opportunities. It is a cycle that can be difficult for service competitors to break into.

The IT industry sector has coined the term System Science, Management and Engineering (SSME) to describe the integration of the disparate elements that comprise IT service solutions: business management, economics and marketing, information management, engineering and computing, service design and service operations. All but the latter two elements are established academic fields, so that SSME is a purposeful aggregation of existing knowledge bases with some specific enhancements. SSME has been defined as "*the application of scientific, management and engineering disciplines to tasks that one person,* *organisation or system beneficially performs for and with another person, organisation or system ('services')"* [9]. It is somewhat of a generalist field that does not fit easily within existing academic boundaries, in a manner reminiscent of computer science. Just as computer science started as an interdisciplinary field, this new generalist field will possibly become a new specialisation, driven by the reductionist environment of academe.

SSME is aimed squarely at the IT sector. Information technology is promoted as a service enabler, especially through the automation of business processes. Automation enables standardization of services, hence reducing the degree of customisation, one of the service attributes. Such service has been described as "productized", whereby the service has assumed some of the attributes of products. This is particularly the case in the financial and insurance sectors, where the term "product" is now widely used to describe some services.

## 3.2 Features of Service

Although tangible products may be engaged in the delivery of a service, they are primarily enablers to the generation and delivery of the service [10]. This challenges the exchange of goods concept that has been the basis of economic theory for many years.

The service sector accounts for about 70-80% of GDP for developed economies, with a similar percentage of employment [11]. Given the extent of its impact, it is important to understand the key attributes of service. A non-exhaustive list of service classes includes: professional consulting, education, finance and insurance, information services, transport, tourism, and consumer retail services. Of these, consumer retail services dominate, which is why consumer sentiment is a critical indicator of economic health.

Service is a non-tangible opposite of a tangible product. While we say that service is "delivered" by a service provider, a service cannot be owned in the same way that a product is (hence it cannot be re-sold). Delivery of service is skills-based and knowledge-based and the valuation of a service derives heavily from the skills and knowledge of the provider. Services are also co-produced with the customer, "customizing" a unique service for each customer. They are difficult to assess before purchase (unlike products that can be inspected) and service generation and consumption are simultaneous. One or more of these service attributes may not apply in every application, especially for complex services, but collectively they provide an appreciation of how service differs from products.

Services have been defined [10] as "the application of specialized competencies (knowledge and skills) through deeds, processes and performances for the benefit of another entity or the entity itself". Other authors offer similar definitions. Four important features of service are offered in [10]:

- Intangible — lacking the palpable or tactile quality of goods
- Heterogeneous — the relative inability to standardize the output of services in comparison to goods
- Inseparable in terms of production and consumption — the simultaneous nature of service production and consumption compared with the sequential nature of production, purchase, and consumption that characterizes physical products
- Perishable — the relative inability to inventory services as compared to goods

Although tangible products may be engaged in the delivery of a service, they are primarily enablers to the generation and delivery of the service. There is a sense that information technology is causing the traditional definition of services to be blurred, as IT allows services to be standardized and "productized"; financial services are an example.

Service has a powerful human element to it, even dominates it, an idea that is only weakly captured by approaching service from a technological (product) perspective, merely offering a technological view of service at the human-machine interface. Human factors engineering, as practiced in system engineering remains a fundamentally technological activity, providing human constraints to the integration of the technical solution.

The description of service provision as a "solution" is a typical term in an emergent language in service science. It is intended to convey the integration of highly dissimilar capabilities, such as physical products and business knowledge, to solve a unique business problem for the customer. It may require the service provider to manage multiple sub-contractors. By buying an integrated package, the "solution", execution of non-core business is simplified for the client organisation, allowing it to focus on its core capabilities.

This "solutions approach" to service delivery is only feasible if the customer trusts the service provider, meaning that relationships are critical. Trust is a social construct which incorporates emotional content, quite distinct from the abstract constructs of product design and system engineering. To gain confidence in the solution, its production must be sufficiently transparent to the customer, especially if regulatory approval is required for the service.

## 4 Service Delivery in a User Paradigm

In contrast with design of the product-service system which occurs in abstract space, service delivery occurs in the user experiential space. Those with a traditional product development background might tacitly assume that service is an inherent feature of the product, somehow embedded within it: from the perspective of the product developer, the user is an extension of the product. The user's viewpoint is quite the opposite: the product is an extension of the user, sometimes even anthropomorphising certain classes of products. Intel Corporation has established a User Experience Group staffed by anthropologists and ethnographers in order to better understand customer patterns of life that determine how its business outputs are used. This group seeks to understand, for example, how situated users (customers) accept certain products as "symbolic markers of cultural practices, gender and even religious identities".

Service satisfaction is not guaranteed merely by meeting the contractual requirements of an outcome-based contract. The user environment has additional complexity that can generate surprising responses, making it difficult to perceive the mind of the customer. Sustainment solutions, because of the service element, are particularly reliant on people behaviours for effective and efficient delivery of service outputs. Human behaviours are dominated by the ancient emotional pathways in the brain that are attuned to provide immediate responses, often driving motor control ("fight or flight"). The cognitive pathways are a more recent evolutionary innovation, and have not yet been provisioned with the same bandwidth as the emotions. In a head-to-head competition, emotions will overpower reason. Even this may be manageable if we could just be aware of what is happening in our ancient emotional pathways, but our deliberative systems cannot monitor and supervise subconscious emotional processing. Human behaviours often run counter to rational, predictable responses because we do not have access to this hidden layer of emotional processing.

Service is delivered in this human experiential layer with its inherent imprecision. Yet humans are equipped to cope with ambiguity: the pre-frontal cortex provides the brain's most impressive capability – adaptation. Learning can be embedded using this adaptive capacity; coping strategies can be developed, the brain's fundamental evolutionary function. Brain activity, learning and adaptation can now be subjected to direct scientific scrutiny as neureoscientists are now showing, confirming the physical adaptation processes that occur.

System thinking, the objective tool that enables technical creation, is silent on how to cope with hidden, non-cognitive processes in service delivery. This is the realm of service thinking, but it is so different from system thinking that it is not readily apparent how to sensibly integrate them. But integrate them we must – the effective delivery of sustainment solutions depends on it. Customer-facing relationships, as critical as they are, are not the only human connections in service systems; those that exist internally amongst the sustainment team need to be considered in the network of relationships. All of the connections and networks throughout the sustainment team can benefit from service thinking.

## 5 Service Thinking in Sustainment Solutions

In the design of product systems, product performance and other requirements are elicited from the customer. References [12] and [13] describe requirements as the "voice of the customer", enabling designers to understand customer intentions. Mostly it is an early activity in the design process, enabling a requirements baseline to be struck. Once the baseline is set, the "voice of the customer" becomes an historical recording. This is very different to service, where there is a continuing dialogue between the customer and service providers.

Service delivery is achieved through a heterogeneous socio-technical system that combines the intangible social cognition of the service team with the tangible product-service system – service delivery requires the "mind of the customer" to be understood. Many contractor "front office" personnel in the case example are in daily face-to-face contact with their customer counterparts. This may be to manage previously defined tasks and plans that have been routinized (such as flight training missions), or to negotiate variations to standard programs (such as fleet maintenance schedules), or to review status of major work tasks and plans. Arisings that occur from routine operations may require the attention of both contractor and customer personnel to design work-arounds; these may have flow-on effects to other standardized tasks that will then also require attention. Especially in the defence sector, the customer may impose urgent (or surge) operational requirements that necessitate significant changes to the design of the sustainment solution, possibly requiring suspension of an existing solution element and design of a new element. To meet these urgent needs, there may be insufficient time to meticulously define the requirements in the usual manner of system engineering; in these circumstances it is helpful, even essential, that the contractor be able to "read between the lines" of the sparse urgent requirement. When the relationship is mature and validated, the contractor can rapidly infer the customer's intentions and act accordingly.

The service system examples offer the idea of connecting with the minds of others ("theory of mind" as it is termed by some in the cognitive psychology literature) as central to service thinking. It enables service teams to attribute desires and intentions to others and to evaluate and explain their likely actions. In a repeating cycle of attunement, evaluation and adaptation, teams learn to anticipate customer aspirations and can adapt in advance. When the cycle becomes habitual, backed up by technical performance (delivering value), the customer develops confidence in the values (future performance) of the team and a state of trust is achieved. In this sense, service satisfaction may be described as *value underpinned by values*.

As social beings, we create representations of the minds of others based on schemas of our own mind [14]-[15]. The brain is an organ of adaptation, and understanding the mind of others is part of its work. There is evidence that our capacity to develop an image of the mind of others is related to our capacity to develop an image of our own mental processes [16]. The fact that a mind can develop a model of itself may be the basis of social cognition [17] – without a sense of self it is impossible to develop a sense of other. Building representations of the minds of others incorporates not merely their focus of attention, but also their desires and intentions, beliefs, attitudes, memories, emotions, patterns of thought and perceptions. Theory of mind enables one to understand the future consequences to others of current actions.

The construction of representations of another's mind for the purpose of deciding on future courses of action can be synthesized into three phases (after [18]):

- Attunement – this involves orienting the focus of attention on the internal world of another, free of judgmental bias, in order to perceive signals relating to their intentions. These intentions may then be mirrored internally. Interaction styles may be classified as: mature/regulated; disorganized; ambivalent; dismissive. A mature/regulated style is essential if signals are to be correctly sensed. Effective attunement provides motivation and energy for downstream action.

- Evaluation – evaluation is a deliberative conceptual activity that appraises the received perceptions to classify or categorise likely responses into schemas of action. Expert teams will have established patterns of practice that facilitate rapid and routine (but effective) responses, but the evaluation must consider whether the required response fits the pre-existing schemas. If not, then adaption is required.
- Adaptation – when the need for change is identified, the team then re-aligns accordingly. Expert teams will adapt quickly to achieve resonance with the customer's intentions, although a degree of negotiation may be required. Effective adaptation requires persistence beyond the initial connection so that harmonization occurs in the long term.

These phases will recur on a regular (even daily) basis to generate a chain of attunement, evaluation and adaptation in order for service delivery to remain aligned to customer thinking. These concepts have been explored to an extent in [19].

## 6 Conclusions

The service thinking style is very different from, yet complementary with, the system thinking style. Sustainment solutions for complex aeronautical product require both thinking styles to be appropriately deployed and harmonised. This is not always easy to achieve for organisations that have long operated in the product paradigm where service has often been regarded as an awkward addendum. The president of Fuji Xerox Co. has acknowledged in the business press [20] the difficulties in trying to shift the corporate business model to a service-orientation: "it is a struggle to shift his back office experts from their customary focus on manufacturing QCD (quality, cost, delivery) and indeed to shift them out of the back office altogether. He wants his experts in the sales force, developing solutions for clients and customers, and understanding that their copier manufacturing company is becoming a service provider". There is anecdotal evidence that other companies making similar shifts are experiencing similar challenges.

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