Designing Collaborative Systems of Systems in support of Multi-sided Markets

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## Working within Ultra-Large-Scale (Eco)Systems*

*Analysis needs to be done across different scales*

<table>
<thead>
<tr>
<th>'Large-scale' Analysis</th>
<th>Establishing economics of alternative ways of delivering force cohesion ‘at the edge’ (e.g. through the use of Tactical UAVs)</th>
</tr>
</thead>
<tbody>
<tr>
<td>'Medium-scale' Analysis</td>
<td>Identifying the interoperability risks across multiple parts of the SoS (e.g. AWACS modernisation)</td>
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<tr>
<td>'Small-scale' Analysis</td>
<td>Analyzing end-to-end asynchronous sensor and data fusion processes (e.g. Multi-Sensor Integration)</td>
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* The challenge is sustaining operational alignment across the different scales

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* Containing large numbers of managerially and operationally independent systems
Outline

1. Engineering in support of an operational space: the need for agility

2. Engineering for a multi-sided market: the need for two kinds of value

3. Engineering two kinds of value: creating value for defense
Defining the relationship between the design space for an operational capability and the operational space within which it will be used

ENGINEERING IN SUPPORT OF AN OPERATIONAL SPACE: THE NEED FOR AGILITY
Defining the Operational Space for Tactical UAV: The Watchkeeper CONOPS

- Land Component Command
- Tactical Air Control
- Watchkeeper
- Fighters on the ground
- Operational Command
- Ground Control Station
- Other operational capabilities

Source: Thales UK, 2005
The evolving definition of an Operational Capability: The example of Tactical UAV

Phoenix and Watchkeeper UAVs were conceived as extensions to existing concepts of operation:

– Phoenix (TUAV I) provided better target acquisition for Multiple Launch Rocket System (MLRS)
– Watchkeeper (TUAV II) provided better servicing of a Commander’s Critical Information Requirements (CCIR)

For TUAVs I & II, the primary focus was on the required capabilities of the system in a design space.
The evolving definition of an Operational Capability: The example of Tactical UAV

Phoenix and Watchkeeper UAVs were conceived as extensions to existing concepts of operation:

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For TUAVs I & II, the primary focus was on the required capabilities of the system in a design space.

The Urgent Operational Requirement (UOR) in Iraq and Afghanistan was for the close coupling of UAV capability to fighters on the ground reflected an increased campaign tempo, and the need for greater tactical agility (TUAV III)

For TUAV III, the focus shifted to the variety of demands on the way the system could be used in the operational space.
The demand for greater tactical agility: the example of mission situations involving the interdiction of fleeting targets

**Mission Situations**

<table>
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<tr>
<th>Controlling issue</th>
<th>Hard to see, effects easy</th>
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**Individual in Afghan-Pakistan border**
*Disrupts terrorist command*

**Individual in Kabul Blue Zone**
*Disrupts terrorist command*

**Stinger Missiles in Baghdad City Centre**
*Neutralization of manoeuvrist threat*

**Shoot-and-Scoot in Tribal Lands**
*Neutralization of manoeuvrist threat*

**Terrorist Escape by Sea**
*Disrupts terrorist command*

What the composite operational capability had to do

Demands/Threats needing different kinds of composite operational capability
The through-life costs of operational use

- The costs of the TUAV III Urgent Operational Requirement (UOR) were of the same order as the planned equipment costs.
- Could the demand for greater tactical agility have been anticipated?
- If so, how could its value have been established?

The cumulative costs of TUAV I & II

TUAV III UOR expenditure:

IPT – Integrated Project Team

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- If so, how could its value have been established?
The demand for Tactical Agility: anticipating the effects of diverging tempos

Divergence of tempos increases demand for UOR solutions

Agility means being able to align composite capabilities to demands/threats at campaign tempo

Divergence of tempos increases costs of alignment

Divergence of tempos increases demand for UOR solutions

Agility means being able to align composite capabilities to demands/threats at campaign tempo

Adapted from: Appropriate Collaboration and Appropriate Competition in C4ISTAR Transformation, Dr Nicholas Whittall RUSI 2007
The variety of mission situations needing support in the operational space far exceeded those anticipated in the design space. Hence the need for agility

- For Tactical UAVs, the original customer intended for the operational capability was the Land Component Commander.
- In practice, the uses of the operational capability formed part of multiple composite capabilities, each one a System of Systems.

The set of operational capabilities supporting these multiple forms of composite capability themselves formed a Collaborative SoS.

How could the engineering of these composite capabilities be supported from within the capability design space?
Designing multi-sided platforms for an operational space defined as a multi-sided market

ENGINEERING FOR A MULTI-SIDED MARKET: THE NEED FOR TWO KINDS OF VALUE
Multi-sided markets: counting the value of indirect market relationships

- A multi-sided market for a supplier is one in which:
  - There is value in its direct ‘one-sided’ relationships with each market participant
  - There is greater value in its indirect ‘multi-sided’ relationships with collaborating market participants
- There has to be more value for the market participant in using the supplier’s platform than not

Multi-sided Platforms: the iPod Touch example

The orchestration of operational capabilities and end-users needed to form the composite capability e.g. the soldier and intelligence officer with face recognition and location-based intelligence.

The context in which the collaboration puts together a composite capability e.g. on patrol in Baghdad.

Demand/threat situation

The Supplier’s Platform providing the means of orchestrating end-users and operational capabilities e.g. iPod Touch

The iPod Touch emerged as the handheld of choice to fulfill the need of each soldier “to be linked electronically to other troops as well as to weapons systems and intelligence sources. Making sense of the reams of data from satellites, drones and ground sensors cries out for a handheld device that is both versatile and easy to use.”

Source: Sutherland, B. (2009, April 27). Apple’s New Weapon: To help soldiers make sense of data from drones, satellites and ground sensors, the U.S. military now issues the iPod Touch. Newsweek.
Defining the Composite Capabilities: the need for tactical agility

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Composite Capabilities

- Intelligence
- Strike Synchronization
- Ship
- Arrest Synchronization
- Communications
- Space Sensors
- High Altitude UAV
- Medium Altitude UAV
- Tactical UAV
- Fast Jet
- Search Helicopter
- Attack Helicopter
- AWACs
- Fast Patrol Boat

Community of Practice

Collaborative SoS

End-users

A Multi-sided Market

Each of these compositions is a system of systems
Substituting a TUAV multi-sided platform: creating indirect benefits through greater flexibility

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### Indirect value

Through its impact on the way different collaborations can be formed.

### Direct value

Through substitution.
Engineering for a multi-sided market

- The multi-sidedness of the operational space (the multi-sided market) defines the need for a supporting Collaborative SoS
- Engineering a platform for a multi-sided market involves creating two kinds of benefit:
  - The direct benefit the platform provides to each of its users
  - The indirect benefit it provides by supporting collaboration between end-users and operational capabilities to form composite capabilities

- The flexibility of a multi-sided platform in support of indirect benefits increases the agility of the force structure in which it participates
Value for Defense is maximized when agility is delivered at minimum cost.

ENGINEERING TWO KINDS OF VALUE: CREATING VALUE FOR DEFENSE
Defining Value for Defense: analyzing the layers of alignment across the different scales

The **direct benefits** of using a TUAV

The costs of the TUAV itself

Costs of Operational Use

Activity-based costs

- Direct Costs + Direct Overheads
- Activity cost drivers
- Operational costs

Costs of Alignment

- Operational Command Costs
- Costs of Orchestration
- Costs of Synchronization

Costs of Cohesion

Value for Defense

The **indirect benefits** from the impact on the costs of alignment

5: Composite (mission) capabilities

4: Fielded Force

3: Operational capabilities

2: Fielded capabilities

1: Equipment & People

Acquisition Tempo

Alignment Tempo

Demand/Threat Tempo

19
Cohesion-based Costing: analyzing the cohesion costs of composite (mission) capabilities

Modeling the variety of composite capabilities

Analyzing the different layers of alignment

Analyzing cohesion costs

Modeling Alignment Processes

Analyzing alignment to demand

Costing Cohesion of Composite Capabilities

The ability to analyze cohesion costs offers:

- The cohesion costs of any particular situation in a campaign
- The range of cohesion costs across a variety of situations arising in different types of campaign
Pricing Agility: *valuing the impact of greater TUAV flexibility*

- **This is what is paid to the supplier**
- **These are the total costs across concurrent campaigns**

**Equipment & other DLODs**

**Defense Enterprise**

**Varieties of Demand**

Acquisition Tempo

Alignment Tempo

Demand/Threat Tempo
Pricing Agility: valuing the impact of greater TUAV flexibility

- ~25% saving from the more flexible TUAV capability
- ~25% saving from using a more flexible TUAV capability
- A further ~12.5% saving from the reduction in range

Baseline average total cohesion cost of the capability

Monte Carlo method is used to generate the range of total cohesion costs across concurrent campaigns

A further ~12.5% saving from the reduction in range
Distinguishing two kinds of value: 

*Determining the maximum price of Value for Defense*

The analysis of total cohesion costs for Concurrent Campaigns delivers:

- A baseline range of costs of supporting this variety of situations
- A lower average cost and a narrower range of costs of delivering this same variety with more flexible TUAV capability

The maximum price of Value for Defense should reflect two kinds of value:

- The direct benefit of greater capability in the platform itself, and
- The indirect benefit of greater force agility arising from the flexibility of the platform

![Graph showing probability of total cohesion costs across Concurrent Campaigns]

- ~25% saving from using a more flexible TUAV capability
- A further ~12.5% saving from the reduction in range
Conclusion

• The need for agility creates new challenges for engineering in support of an operational space.

This involves understanding the impact on the design space of variety of use in the operational capability space.

• This variety of use can be approached in terms of the multi-sidedness of the market into which capabilities are being deployed

This leads to designing platforms for multi-sided use within an operational space.

• Creating value for defense therefore involves an engineering approach that can generate indirect as well as direct benefits

Such engineering depends on being able to define both kinds of Value for Defense.
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