# Digital Twin Community of Practice – Flares Investigation Tasks Overview

An overview of a TD-info, industry and MOD collaboration project to define and demonstrate the viability of Digital Twin benefits for MOD countermeasures (Flares).

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# Contents



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# Who are Team Defence?

1. Team Defence is a not-for-profit membership organisation funded by industry that harnesses and co-ordinates volunteer contributions from its 167 members and the MOD

2. A collaborative association that informs Defence policy and pilots new ways of working to transform the Defence ecosystem

3. Team Defence is exceptional in the way it pursues obtaining a wider understanding for Defence

4. Provides coherence, common solutions and corporate memory

5. 21 People , 3 full time, 2 part-time, 1 secondee and 14 specialist part time Defence consultants


| | | | |
|---|---|---|---|
| Agenda set by MOD & Industry – DISCOG & JIG | Promotes early requirements setting | People, Process & Technology – all of them | Small to Medium Enterprises *and* Major Suppliers are members |
| Vendor agnostic but need to know Art of the Possible | Coherent & Pragmatic Solutions | Team Defence Body of Knowledge – grow & exploit | Cultural change |
| Promotes Innovation & Agility | For mutual benefit - shared solutions for the common good | International Standards & being interoperable | Skills, Learning & Professional Development |

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# Community of Practice – Digital Twin Wider Landscape

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**Multi Domain Operations**: Federation of twins and models across complex landscape. Investigating Defence data models and national Digital Twin Information Management Framework

**Accelerating Capability**: Use of MBSE models to design, develop and integrate next generation capabilities and **utilize** the models through life. Using FCAS as the basis for development but also potential with Dreadnaught

Test & Evaluation: Use of digital and synthetics combined with live testing to reduce cost and effectiveness of future T&E. Developing a proof of concept (Terrain, Weather, 2x UAV's) on a private range in Wales, next stage introduce flares

Engineering Support: Exploiting platform condition and usage data combined with design documentation to improve availability, reliability, support and performance through life. Working to Identifying pilots.

**Supply Chain**: Optimising both process and network to assure cost effective and efficient delivery of supply. Starting with data analysis to identify MVP based on single node and connector

**Cyber Physical Security**: Considering how the cyber physical risks of digitization ad twins in order to identify policy practice and process to protect.

**Safety & Engineering** : Moving from document based safety decisions to a digital safety case. Reviewing an developing safety policies and standards to ensure digital decisions are recognised by the regulatory authorities

**Knowledge base**: Creating a map of digital twin activities and contacts in order to learn and share lessons from

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# Definitions

- The phrase Digital Twin can hold many varying meanings depending on the industry and the purpose required. It is therefore important to define specifically what is meant by Digital Twin in the context of the proposed tasks.

**What is a Digital Twin?** "A Digital Twin is a connected data representation of an entity, such as a physical asset, a process or system throughout its lifecycle." (As defined by the first 'Digital Twin for Defence Engineering Support' White Paper – September 2019)

Overarching definitions in this setting (can be an asset, product, service, or enterprise) in most circumstance a mix or amalgamation of all these.

- Digital Twin – Connected both ways from 'real' to Digital.
- Digital Model – Not connected to 'real.'
- Digital Shadow – Connected one way from 'real' to Digital.

To summarise, a Digital Twin is best described as a visualisation and scenario builder to assist with decision making.

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# The Digital Twin Community of Practice

The Digital Twin workstream has been active since 2019, has attracted 650+ members, and has explored the introduction of a  synthetic environment to support frictionless access of data at appropriate authorization.

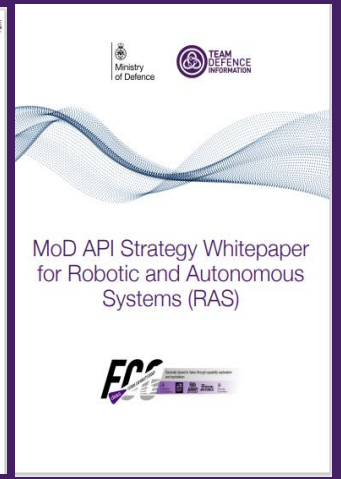
The ideal future solution is an ecosystem of Digital Twins across the entire Defence enterprise which enable timely and useful decision, design and capability support.

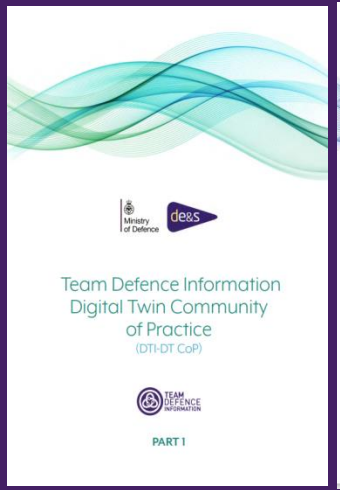
| | | | |
|---|---|---|---|
| 18 Months | 100+ Contributors | 50+ Organisations | 3 White papers |
| 25+ Presentations | 3 Conferences | 900+ Attendees | 1000+ Downloads |

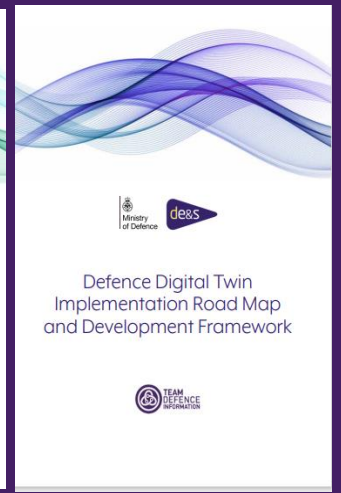
**Previous White Papers:**

1. Digital Twin For Defence Engineering Support
2. Digital Twin Implementation Roadmap and Development Framework
3. Information Architecture for Digital Engineering Support
4. DT application in Defence (How does RAS impact)

Click links to access papers

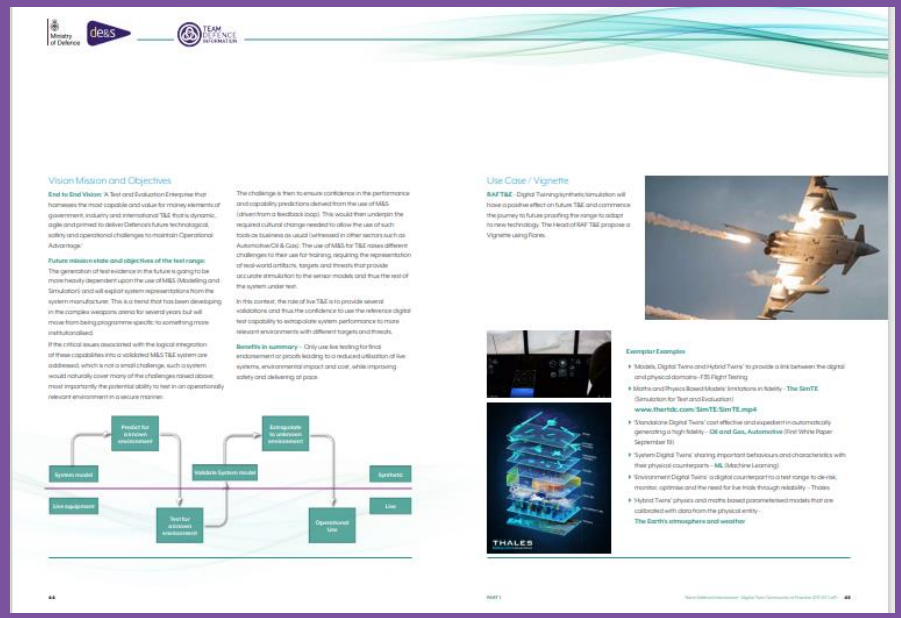



# The Digital Twin Community of Practice

- As an illustration of previous investigations being developed further, the third white paper - section 5, recounts a visit to MOD Aberporth Range, where the challenges around Test & Evaluation of aircraft stores was made apparent.
- As evidenced within the completed investigation, the upcoming tasks have been created as a direct result of its findings and attempts to demonstrate practical Digital Twin solutions.

# Team Defence Information General Process Road Map

1. MOD Stakeholder Requirements and Instructions provided to Team Defence.

2. Team Defence creates a task overview with MOD Stakeholders.

3. Team Defence organises project resources, reaching out to the wider community.

4. Team Defence manages relevant community engagement.

5. Team Defence output achieved (White Paper).

6. Team Defence does a wider brief out if required.

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# Project Context and Anticipated Outcomes

***Context – why is this project of relevance to the MOD and supporting organisations?***

The field of Digital Twins as a whole holds incredible possibilities within the entire defence landscape.
In the case of air countermeasures – specifically flares – the ability for them to provide a decoy is a well-established concept and has been in service in the RAF since the 1960s with the Vulcan bomber. Not only is it relevant for today as a countermeasure, it will also be relevant for the foreseeable future.

Digital simulations and representations of flares systems have the potential to provide the MOD with an improved design, test, evaluation and through life support capability for its countermeasure assets. MOD have selected five topics for the Digital Twin Community of Practice to help them understand new approaches.

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# Project Strands Statement of Requirements

- Strand 1: Safety Trace
- Strand 2: Environmental Testing Review
- Strand 3: Consultation over Design of Experiments
- Strand 4a: Composition - Combustion Modelling
- Strand 4b: Dynamics Of Mixing
- Strand 5: Asset Tracking

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# Why get involved?

Your contribution will enable you to understand the direction of travel from within Defence, shape, influence and assist towards MOD countermeasure development

There is also the opportunity to work as part of a team with equally capable and knowledgeable organisations within Defence and the wider digital community.

This is an opportunity for other industry experience and best practice to be showcased within the defence environment

**This will enable:**

- Understanding of how focus areas will federate and interact to realize a future end state
- Articulation of requirements for Federated Digital Twinning capability across the enterprise
- Development of capability roadmaps
- Alignment, pull through and learning from representative Digital Twining capabilities
- Assessment of potential system solutions and recommendations for capability development

**Demonstrate Digital Twins capabilities that are available for employment today – providing:**

- Rapid cost reduction opportunities
- Rapid T&E operational/technical benefit
- A live testbed to learn how to integrate/federate additional capabilities/Digital Twins in the future.

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# Tiers of Involvement

For participants of this activity, the tasks have been divided into categories of expected involvement and time commitments. This will allow a level of pre-determining of commitment, accountability and roles of responsibilities.

| Support Category | Role/involvement | Expected time commitment |
|---|---|---|
| **Task Lead** | Have final editorial rights and lead the task | Up to half day a Week |
| **Authors** | Develop written content for sections of the document | 1-2 days a Month |
| **Reviewer** | Peer review of document as it develops from strawman to final draft | Half day a Month |
| **Contributors** | Provide documents, reports and case studies to the initial stages and build the cross-sector evidence base | Limited time at initial stages of task plus attendance at final presentation |
| **Interested Parties** | Join at start up, attend the final presentation out brief and receive the final paper | Minimal effort just tracking activity and exploiting the outputs |

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# Strand Involvement Criteria

- We very much appreciate any expression of interest in future involvement with this investigation. Whilst every opportunity will be made to facilitate participation, it is important to note that the MOD customers have specified they are looking for certain subject matter experts for each of the strands with relevant or applicable experience and expertise.
- This is not a pitching opportunity for Business Development.
- Apply in the first instance to the forthcoming online registration page which will request from interested parties:
    1. What Strand(s) are being committed to
    2. Your tier of involvement (slide 12)
    3. What makes you a suitable participant for this investigation

- Team Defence, working with the project sponsors, will review all applications and will notify all applicants of their outcome once the process has been completed.
- Involvement will depend on what you want to do, which strand you want to assist, the level of support you are offering.
- This due diligence is to ensure that appropriate subject matter experts are assigned to each task and to enable Team Defence to effectively plan out the investigation schedule alongside MOD stakeholders.

# Sponsorship and Stakeholders

**Sponsors**

- Wing Commander Chris Greenwood | SO1 Protection of Air Operations | Air Capability Strategy

The stakeholders involved:

1. Safety Trace – RAF & Dstl - Squadron Leader Paul Sanders/Mark Bishop, Peter Taylor
2. Environmental Testing Review - MOD - Andy Pickerill
3. Consultation Over Design of Experiments - Dstl - Mark Bishop (Dan Kent and Jon Polehampton)
4. Composition/Dynamics of Mixing/Combustion - Dstl - Mark Bishop/Matt Wood (plus CCM)
5. Asset Tracking - DE&S – Stephen Searles

# Project Stakeholders

**Volunteer Task Force**

- Software Developers
- Data Scientists
- Simulation and Modelling
- Engineers

**Industry**

- Chemring

**MOD**

- DSTL
- DE&S
- RAF
- RAF RCO

**Digital Twin Community of Practice**

- Assigned following Call to Action

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# Proposed Route Timeline (pace balanced with outputs and MOD sponsor bandwidth)

- Requirements sent to TDI – Done.
- Feedback provided on requirements by TDI - Done.
- Revised requirements formalised - Done.
- Digital Twin community of practice briefing via an online event – Today.
- Expressions of interest sent out to Digital Twin community of practice (TBC)
- TDI arranges Subject Matter Workshops (TBC)
- Outputs published and potential webinar brief out (TBC)

# Close Out

Thank you for expressing interest in supporting this innovative and exciting initiative.

If you have any questions or require any additional information, please get in touch via the contacts provided at the end of this pack.

Link to sign up once created

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# Nomenclature / Abbreviations

| Term | Definition |
|---|---|
| DE&S | Defence Equipment & Support |
| Dstl | Defence Science and Technology Laboratory |
| DT | Digital Twin |
| FCG | Future Capabilities Group |
| MOD | Ministry of Defence |
| MVP | Minimum Viable Product |
| PID | Project Initiation Document |
| RAF | Royal Air Force |
| RCO | Rapid Capabilities Office |
| SME | Subject Matter Expert |
| T&E | Test & Evaluation |
| TDI | Team Defence Information |

# TDI Contact Details


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# Wg Cdr Chris Greenwood

## SO1 Protection of Air Operations, HQ Air Command

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# Flares Investigation (Aircraft Countermeasures) Requirements Summary

The following summaries have been provided directly from MOD task leads and have elaborated detailed requirement document that will accompany each strand.

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# Summary of Requirements Review

1. Safety Trace

2. Environmental Testing Review

3. Consultation Over Design Of Experiments

4a) Composition – Combustion Modelling
4b) Dynamics of Mixing

5. Asset Tracking

Taguchi, $P = 5, L = 2$

| Run # | a | b | c | d | e | X |
|---|---|---|---|---|---|---|
| 1 | 1 | 1 | 1 | 1 | 1 | X |
| 2 | 1 | 1 | 1 | 2 | 2 | X |
| 3 | 1 | 2 | 2 | 1 | 1 | X |
| 4 | 1 | 2 | 2 | 2 | 2 | X |
| 5 | 2 | 1 | 2 | 1 | 2 | X |
| 6 | 2 | 1 | 2 | 2 | 1 | X |
| 7 | 2 | 2 | 1 | 1 | 2 | X |
| 8 | 2 | 2 | 1 | 2 | 1 | X |

# Stakeholder Summary

**MOD:**The Ministry of Defence is the department responsible for implementing the defence policy set by His Majesty's Government

**Dstl (Defence Science and Technology Laboratories):** is one of the principal government organisations dedicated to science and technology in the Defence and security field. It supplies specialist services to MOD and wider government, working collaboratively with external partners in industry and academia worldwide, providing expert research, specialist advice and invaluable operational support.

**DE&S (Defence Equipment and Support):** Delivers equipment and support services to the Royal Navy, British Army, and Royal Air Force.

**RAF (Royal Air Force) :** For over a hundred years the RAF has defended the skies of Britain and projected Britain's power and influence around the world. It works with UK and international partners to watch the skies, respond to threats, prevent conflict, and provide, assistance in an uncertain world.

**Chemring:** Chemring Countermeasures Limited designs and manufactures RF and IR countermeasures that are devised to protect air and naval platforms from missile threats.

Click image of relevant department (to the right) to be taken to the relevant website for more information.

# 1. Safety Trace
## Paul Sanders, Peter Taylor

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# Strand 1. Safety Trace

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| 1-10 COP Engagement Checklist |
| --- |
| **1 – What are we looking for?** – This task is to develop and verify a model/tool that can predict the flight trajectory and ground impact location of in-flight ejected flares and associated components for both burning and non-burning flare countermeasures. A failure mode analysis is also required, and It is recommended that an analysis is conducted to ascertain which components of the flare constitute a valid hazard to 2nd/3rd parties, what represents a reputational risk to the MoD, and therefore what components must be modelled in order to ensure a valid safety trace. This also includes thrusted or kinematic flares. |
| **2 – Who is looking for it?** – RAF & Dstl - Squadron Leader Paul Sanders/Mark Bishop, Peter Taylor |
| **3 – First level of description?** - To accurately predict the flare flight path (trajectory) based on from ejection forces, aerodynamic forces and influence of burn material. The overall aim is to maximise safety when conducting flare trials, minimizing risk to 2nd and 3rd parties and ensuring components of tested flares remain outside areas accessible to the public. |
| **4 – Description of MOD Divisions** – For RAF and Dstl descriptions refer to slide [3] |
| **5 – Technical description** – The aim of the flare safety trace is to ensure that safety is maximised when conducting flare trials and flare firings. As such, if calculated and applied correctly it should ensure two things; Trials risks are minimised to 2nd and 3rd parties, and components of the flare should remain outside areas that are accessible to the public. |
| **6 – Work to date** – None |
| **7 – Support standards/protocols** – Current parameters and assumptions provided in SoR. |

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# Strand 1. Safety Trace

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| 1-10 COP Engagement Checklist |
| --- |
| **8 – TRL level are we looking for?** – TRL 7 – System prototype demonstrated for use in a typical product development scenario. |
| **9 - IP** – No IP required as project involves analysis of current modelling method and the application of already utilised DoE methods in other industries. IP can be offered by owners if they wish to and if it will add value to the project. |
| **10 – Time frames and line of sight for funding** – This is a voluntary, free of charge sets of tasks, however, your contribution will enable you to understand the direction of travel from within Defence, shape, influence and assist towards MOD countermeasure development |


# 2. Environmental Testing
## Andrew Pickerill

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# Strand 2. Environmental Testing Review

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| 1-10 COP Engagement Checklist |
| --- |
| **1 – What are we looking for?** – To explore the potential for digital modelling methods for environmental testing of OME to support the Safety and Environmental Case Report (SECR) process. If unachievable, a review of the current qualification process is welcome. |
| **2 – Who is looking for it?** – DE&S - Andy Pickerill |
| **3 – First level of description?** – The qualification process is all encompassing and requires a lot of different dynamic tests that are complex in nature. Due to operational needs (URD/SRD) the OME item is tested to extreme environmental specification levels, which in turn lends to a lengthy qualification programme and often results in an over test of OME, leading to a reduced life. |
| **4 – Description of MOD Divisions** – For DE&S description refer to slide [3] |
| **5 – Technical description** – To propose valid adaptations to current qualification methods that should reduce environmental testing time or severities. Additionally, it is desired any proposed qualification method will avoid over-testing the OME. |
| **6 – Work to date** – WQIP published a white paper (culture change – Risk Based Approach). Ian Carr (Head of Munition Life Assessment) wrote a paper on “The Calculation of Air Carriage Hours Clearances Prior to ISD and Life Extension”. DOSG produced an S3 procedure document to guide delivery teams and the DA on the route to qualification. |
| **7 – Support standards/protocols** – DSA O.2 OME, Compliance with ASEMS. Procurement of OME must adhere to DSA 0.2 OME Regulations, within the regs the standards to follow are listed i.e., Def Stan, STANAG, etc. |

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# Strand 2. Environmental Testing Review

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| 1-10 COP Engagement Checklist |
| --- |
| **8 – TRL level are we looking for?** – Realistically TRL 2 – Technology concept formulated. Aspirational TRL 6 – Technology demonstrated in relevant environment. |
| **9 - IP** – No IP required as project involves analysis of current modelling method and the application of already utilised DoE methods in other industries. IP can be offered by owners if they wish to and if it will add value to the project. |
| **10 – Time frames and line of sight for funding** – This is a voluntary, free of charge sets of tasks, however, your contribution will enable you to understand the direction of travel from within Defence, shape, influence and assist towards MOD countermeasure development |

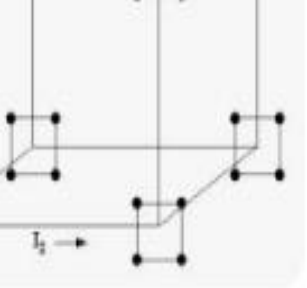

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Fig 1.1 – Orthogonal Array Selection Table

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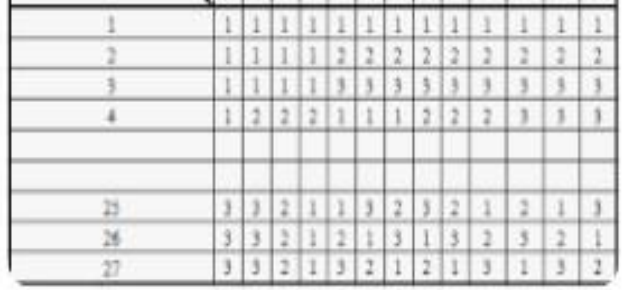
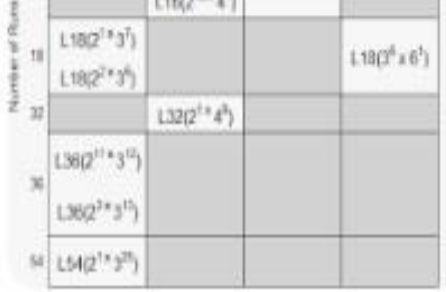
Design of Experiment in Taguchi Method ...



Scientific & Academic Publishing
Employ the Taguchi Method to Optimize...

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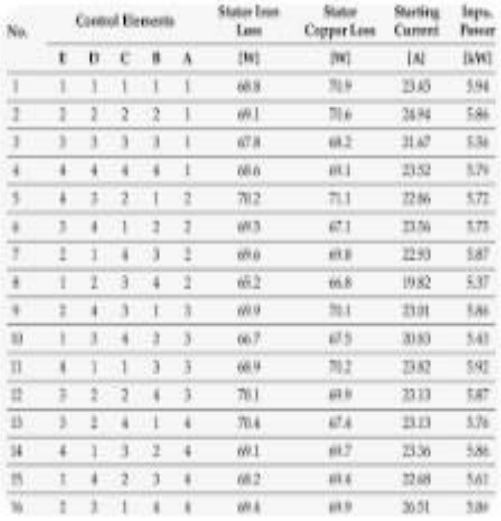
Taguchi Orthogonal Array (OA...

ResearchGate
L12 orthogonal

Taguchi Orthogonal Arra...



ResearchGate
Orthogonal array L16 matrix by ...

| Experiment Number | Column 1 | 2 | 3 | 4 |
|---|---|---|---|---|
| 1 | 1 | 1 | 1 | 1 |
| 2 | 1 | 2 | 2 | 2 |
| 3 | 1 | 3 | 3 | 3 |
| 4 | 2 | 1 | 2 | 3 |
| 5 | 2 | 2 | 3 | 1 |
| 6 | 2 | 3 | 1 | 2 |
| 7 | 3 | 1 | 3 | 2 |
| 8 | 3 | 2 | 1 | 3 |
| 9 | 3 | 3 | 2 | 1 |

University of York
Orthogonal Arrays

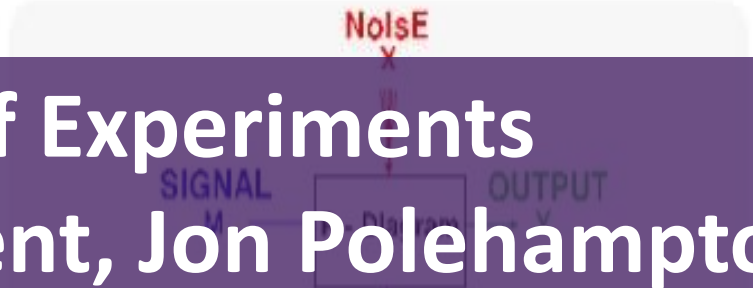
Taguchi, $P = 5, L = 2$

| Run # | a | b | c | d | e | X |
|---|---|---|---|---|---|---|
| 1 | 1 | 1 | 1 | 1 | 1 | $X_1$ |
| 2 | 1 | 1 | 1 | 2 | 2 | $X_2$ |
| 3 | 1 | 2 | 2 | 1 | 1 | $X_3$ |
| 4 | 1 | 2 | 2 | 2 | 2 | $X_4$ |
| 5 | 2 | 1 | 2 | 1 | 2 | $X_5$ |
| 6 | 2 | 1 | 2 | 2 | 1 | $X_6$ |
| 7 | 2 | 2 | 1 | 1 | 2 | $X_7$ |
| 8 | 2 | 2 | 1 | 2 | 1 | $X_8$ |

www.me.psu.edu
Taguchi Orthogonal Ar...

| | Outer Array $L_4$ | L | 1 | 1 | 1 | 1 |
|---|---|---|---|---|---|---|
| | | M | 1 | 1 | 2 | 2 |
| | | N | 1 | 2 | 1 | 2 |
| | Inner Array $L_9$ | | | | | |
| Trial | A | B | C | D | | |
| 1 | 1 | 1 | 1 | 1 | 23.2 | 22.5 | 26.7 | 28.4 |
| 2 | 1 | 2 | 2 | 2 | 20.1 | 24.5 | 22.2 | 26.5 |
| 3 | 1 | 3 | 3 | 3 | 26.5 | 27.8 | 22.4 | 23.1 |
| 4 | 2 | 1 | 2 | 3 | 32.2 | 28.4 | 27.3 | 24.5 |
| 5 | 2 | 2 | 3 | 1 | 21.5 | 22.2 | 28.1 | 26.4 |
| 6 | 2 | 3 | 1 | 2 | 20.7 | 23.1 | 28.9 | 25.3 |
| 7 | 3 | 1 | 3 | 2 | 22.2 | 30.1 | 22.1 | 29.3 |
| 8 | 3 | 2 | 1 | 3 | 26.3 | 23.1 | 25.3 | 24.6 |
| 9 | 3 | 3 | 2 | 1 | 24.5 | 24.2 | 34.5 | 23.1 |

Six Sigma Study Guide
Taguchi Robust Design and Loss F



# 3. Design Of Experiments

## rk Bishop, Dan Kent, Jon Polehampton

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# Strand 3. Consultation Over Design Of Experiments

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| 1-10 COP Engagement Checklist |
| --- |
| **1 – What are we looking for?** – The requirements for implementing 'Design of Experiments' approaches such as the Taguchi approach to existing CM modelling approaches. (https://en.wikipedia.org/wiki/Taguchi_methods) |
| **2 – Who is looking for it?** – Dstl - Mark Bishop, Dan Kent and Jon Polehampton |
| **3 – First level of description?** – Description of how a statistical approach to experimental design can increase the efficiency of the development and design process. |
| **4 – Description of MOD Divisions** – Dstl - Refer to slide [3] |
| **5 – Technical description** – Approaches such as the Taguchi approach are traditionally used to identify and reduce the occurrence of defects and failures. This type of experimental design will identify factors that influence variability and will show, through statistical analysis, which factors have the greatest influence and whether they are controllable or uncontrollable factors. |
| **6 – Work to date** – All experimental design within the Future Pyrotechnic Solutions Team at Dstl to date has been based on an iterative process and many years of design experience. The statistical approach has not previously been used within the team. |
| **7 – Support standards/protocols** – There are no particular standards, or processes that need to be followed to achieve a suitable way of applying a statistical method to our design of experiments. |

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# Strand 3. Consultation Over Design Of Experiments

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| 1-10 COP Engagement Checklist |
| --- |
| **8 – TRL level are we looking for?** – TRL 8 – Actual system completed and qualified through test and demonstration. |
| **9 - IP** – No IP required as project involves analysis of current modelling method and the application of already utilised Design of Experiments methods in other industries. IP can be offered by owners if they wish to and if it will add value to the project. However, if a new or different statistical approach is found to be more suitable for this application, then that might change. |
| **10 – Time frames and line of sight for funding** – This is a voluntary, free of charge set of tasks. However, your contribution will enable you to understand the direction of travel from within Defence, shape, influence and assist towards MOD countermeasure development. |

# 4A. Composition - Combustion Modelling

Mark Bishop, Dan Kent

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# Strand 4A. Combustion Modelling

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## 1-10 COP Engagement Checklist

**1 – What are we looking for?** – The purpose of the task is to further develop our understanding of the behaviour of pyrotechnic pellets and be able to graph the relationships between pellet design features such as surface area and cross-section, and their corresponding burn properties such as burn rate and electro-optic emissions.

**2 – Who is looking for it?** – Dstl (Daniel Kent) – This will be used to expedite the process of generating digital models of countermeasures based on experimental countermeasure designs and will also be used to expedite the process of creating novel countermeasure designs that deliver specific burn requirements.

**3 – First level of description?** – To develop a capability that allows the expected burn properties of an MTV pellet to be modelled based on the physical design of the pellet and the MTV composition used. Conversely, the capability will also allow us to take a desirable burn performance, as identified by simulation studies, and be able to generate the necessary pellet design to achieve that performance.

To achieve this will require the application of the fundamental laws of pyrotechnic combustion and the review of existing pyrotechnic combustion data in order to start identifying and detailing links between pyrotechnic pellet designs and the resulting burn characteristics. Where data does is not readily available, the completion of burn tests may be required to obtain said data.

**4 – Description of MOD Divisions** – Dstl - Refer to slide [3]

**5 – Technical description** – The solution needs to be able to take the shape of a pyrotechnic pellet, details of the pyrotechnic composition the pellets are made of and the density of the pellet, all as inputs, and be able to output a reasonably accurate suggestion of how the combustion of the pellet would progress over time and what the emission from the pellet would be in certain electro-optic wavebands over time. Conversely, the system should also allow the user to input an emission over time profile, and the system will then provide a suggestion of a suitable pellet shape that give the emission over time profile when combusted. The user should also be able to set limits on certain pellet shape dimensions. It is also desirable that certain burn inhibition effects such as pellet hardware be included.

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# Strand 4A. Composition - Combustion Modelling

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| 1-10 COP Engagement Checklist |
| --- |
| **6 – Work to date** – A very basic emission profile has been constructed using a very limited set of countermeasure data. The accuracy of the resulting emission profile is yet to be verified. |
| **7 – Support standards/protocols** – If conducting additional burn testing, there are standard methods of burn testing that are employed by both Dstl and CCM that should be utilised. |
| **8 – TRL level are we looking for?** – TRL 8 – Actual system completed and qualified through test and demonstration of a typical countermeasure development scenario. |
| **9 - IP** – No IP required as project involves analysis of current modelling method and the application of already utilised DoE methods in other industries. IP can be offered by owners if they wish to and if it will add value to the project. |
| **10 – Time frames and line of sight for funding** – This is a voluntary, free of charge set of tasks. However, your contribution will enable you to understand the direction of travel from within Defence, shape, influence and assist towards MOD countermeasure development. |



# 4b Dynamics Of Mixing

Mark Bishop , Dan Kent

Ministry of Defence

# Strand 4B. Composition - Dynamics Of Mixing

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## 1-10 COP Engagement Checklist

**1 – What are we looking for?** – An investigation and development of a robust model for simulating the mixing of pyrotechnic materials, and other highly solid-loaded systems, to enable rapid experimentation and optimisation of proposed manufacturing methods throughout the development lifecycle and scale-up into mass manufacture.

**2 – Who is looking for it?** – Mark Bishop (DSTL) plus Chemring Countermeasures (CCM)

**3 – First level of description?** – The aim is to enhance understanding of the process and to enable more rapid mixing optimisation and scale-up in a manufacturing environment to achieve consistent and high-quality resultant product.

**4 – Description of MOD Divisions** – Dstl - Refer to slide [3]

**5 – Technical description** – The focus will be on characterising flow dynamics, interfacial interactions and rheological properties involved in the mixing process. The aim is to enhance understanding of the process and to enable more rapid mixing optimisation and scale-up in a manufacturing environment to achieve consistent and high-quality resultant product. It is important for the user to be able to enter data for their substances to assist in formulation and process design.
This activity may wish to consider typical technologies, such as orbital planetary mixing, as well as disruptive technologies, such as double-action centrifugal mixing (e.g., Speemixer by Hauschild) and resonant acoustic mixing (Resodyn mixer technologies).

**6 – Work to date** – Some exploratory works were presented at the Royal Society of Chemistry Formulation Science & Technology Group conference ‘Modelling and Simulation in Formulations’ in July 2022 (Formulation Science & Technology Group - Modelling and Simulation in Formulations 2022).

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# Strand 4B. Composition - Dynamics Of Mixing

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| 1-10 COP Engagement Checklist |
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| **7 – Support standards/protocols** – For the purposes of this task, pyrotechnic materials can be considered as multi-material systems based on solid particles and colloidal non-newtonian liquids. Typically, these materials will contain 80% or more by weight of solid materials. |
| **8 – TRL level are we looking for?** – TRL 7 – System prototype demonstrated for use in a typical product development scenario. |
| **9 - IP** – No IP required as project involves analysis of current modelling method and the application of already utilised DoE methods in other industries. IP can be offered by owners if they wish to and if it will add value to the project. |
| **10 – Time frames and line of sight for funding** – This is a voluntary, free of charge sets of tasks, however, your contribution will enable you to understand the direction of travel from within Defence, shape, influence and assist towards MOD countermeasure development |


# 5. Asset Tracking
## Stephen Searles

Ministry of Defence

# Strand 5. Asset Tracking

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## 1-10 COP Engagement Checklist

**1 – What are we looking for?** – An overall improvement to the current inventory and storage management systems, assessing the ability to digitalise some of the currently manual processes for asset management (recording usage of the items e.g. hours flown, what platform etc.) and to provide, if possible, a "cradle to grave" management system.

**2 – Who is looking for it?** –DE&S – Stephen Searles

**3 – First level of description?** - Air Countermeasures (CMs) are subject to a series of lifing categories that impact their storage, use and disposal. Management of these lifing categories is required and is carried out to ensure CMs are safe and within acceptable use life.

**4 – Description of MOD Divisions** – DE&S - Refer to slide [3]

**5 – Technical description** – A countermeasures "life" ends when whichever lifing category is reached first.
Each CM has agreed figures for each of the lifing categories which are signed off by the design authority (Chemring CM) and there may be different limits for the same CM on different aircraft and different limits for the same CM in different locations on the aircraft.
The lifing categories are established through design/testing and often additional testing activity following a period of service. Each CM's limitations are recorded on the Certificate of Design issued by the design authority and are reflected in safety and operational documents.

**6 – Work to date** – CMs are held on Depot stock system (Astrid) as A3, until issued forward to units. They are then held on unit stock system (MJDI) until issued forward to the users. The users then manually manage the recording of hours/days etc by writing on the items and recording details on a local excel tracker. Once life expired the items are usually disposed of locally however some may come back into stock and are accounted for on the respective systems under a different stock condition code e.g. B4 or D2.

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# Strand 5. Asset Tracking

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| 1-10 COP Engagement Checklist |
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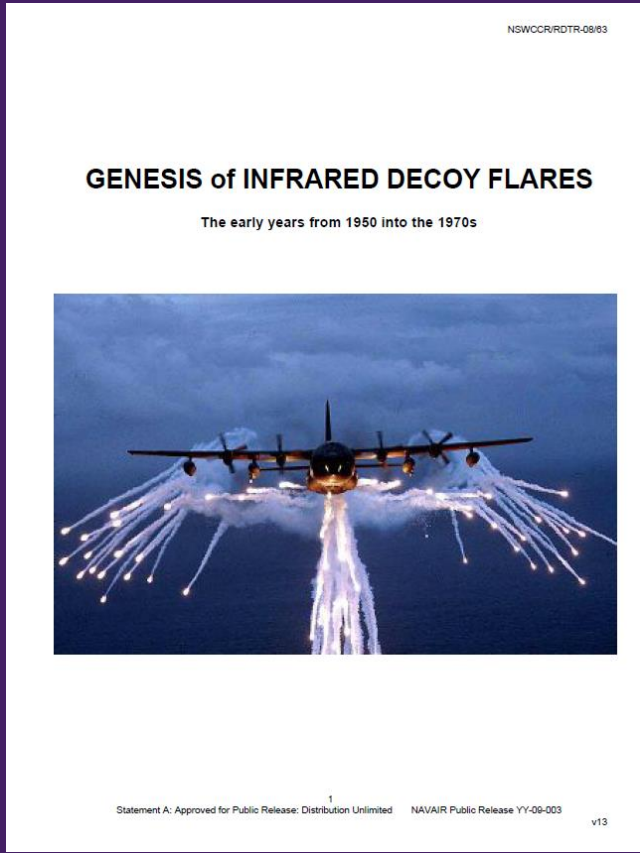
| **7 – Support standards/protocols** – Lifing categories provided. Generic examples are enclosed in the SOR. The limits relating to each lifing category may need to be communicated (if possible) unless hypothetical ones can be used for the purposes of this project (may affect validity). |
| **8 – TRL level are we looking for?** – TRL 5 – needs to be able to function. |
| **9 - IP** – No IP required as project involves analysis of current modelling method and the application of already utilised DoE methods in other industries. IP can be offered by owners if they wish to and if it will add value to the project. |
| **10 – Time frames and line of sight for funding** – This is a voluntary, free of charge sets of tasks, however, your contribution will enable you to understand the direction of travel from within Defence, shape, influence and assist towards MOD countermeasure development |

# Flares Summary and Further Reading…


NSWCCR/RDTR-08/63

GENESIS of INFRARED DECOY FLARES

The early years from 1950 into the 1970s

1

Statement A: Approved for Public Release: Distribution Unlimited NAVAIR Public Release YY-09-003

v13

*'Genesis of Infrared Decoy Flares'*
*A great further reading resource.*

A flare or decoy flare is an aerial infrared countermeasure used by a plane or helicopter to counter an infrared homing ("heat-seeking") surface-to-air missile or air-to-air missile. Flares are commonly composed of a pyrotechnic composition based on magnesium or another hot-burning metal, with burning temperature equal to or hotter than engine exhaust. The aim is to make the infrared-guided missile seek out the heat signature from the flare rather than the aircraft's engines.

**Chemring:**

MTV - Flare CM 118 Mk3 Type 1

Source: https://www.chemring.com/what-we-do/countermeasures-and-energetics/advanced-ir-countermeasures/uk

The 118 Mk3 Type 1 flare is used in aircraft countermeasure systems to combat heat-seeking missiles. The impulse cartridge is fitted during manufacture of the flare and provides the means of ejecting the payload.

Produced to UK MOD requirements, this MTV flare is used with NATO and multiple overseas air forces on a range of light attack/trainer and transport aircraft including helicopters.

The provided publication (left) provides an oversight to the development and introduction of Infrared Decoy Flares between the 1950s and 1970s in the USA. Despite being a US orientated piece, it provides a detailed background on IR flares.

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