



**SEAS** DTC

Systems Engineering for Autonomous Systems  
Defence Technology Centre

## **Plenary Session 3**

**DTC Programme : Lessons  
Learned / Future Expectations**

## ***Agenda***

- **Systems Engineering Integration Review**

*Darren Ansell, Systems Engineering Integration Team Leader*

- **Lessons Learned**

*Tim Doggart, SEAS DTC Programme Manager*

- **Expectations for the Programme**

*Bill Bardo, Technical Director*

## ***Agenda***

- **Systems Engineering Integration Review**

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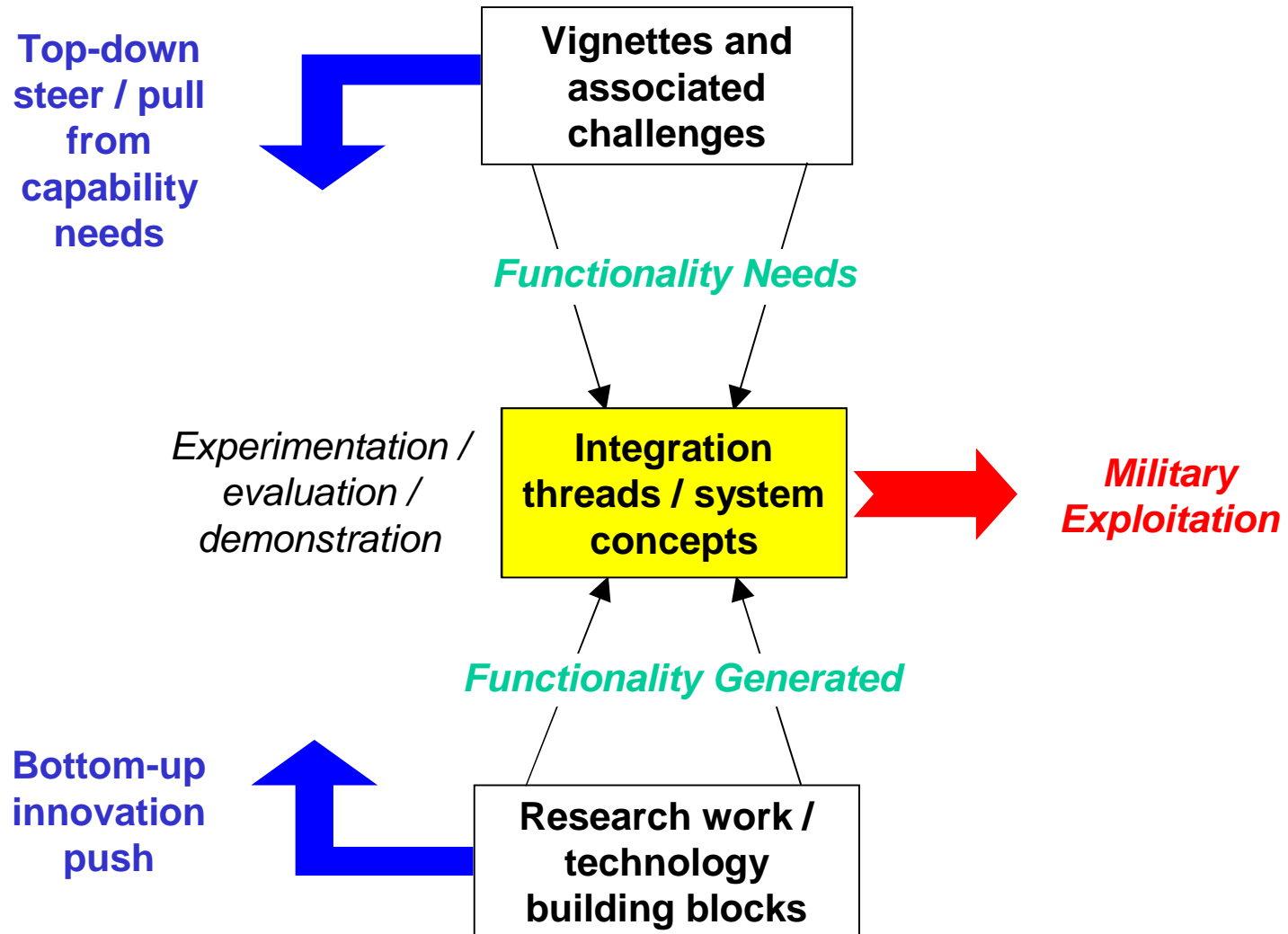
- **Lessons Learned**

*Tim Doggart, SEAS DTC Programme Manager*

- **Expectations for the Programme**

*Bill Bardo, Technical Director*

## The SEAS DTC's Exploitation Model



## ***SEI004 - Kennedy Carter iUML Investigation***

### **Research questions:**

- 1. Can executable UML be used to help us implement (and subsequently investigate the performance of) an autonomous system concept ?**
- 2. Is the KC toolset going to be useful for integrating code from our research community (e.g. Matlab, C++, Java, etc) ?**
- 3. Can we implement a 'DTC thread' using executable UML as the scheduler and implement and demonstrate it using the KC tool ?**
- 4. Can our researchers use the tool to re-engineer their algorithms into executable UML ?**
- 5. Can we demonstrate forward generation of DTC research into company preferred code sets, e.g. SPARK ADA?**
- 6. Can we (in doing this) demonstrate that we are reducing the time period from research into exploitation ?**

***Sanitise Area and Detect Anomalies – UAV detects changes in the scene under study (SEN001)***



***Achieve Goal – investigate detected changes (SER001)***



Visualisation provided  
by Virtual Battlespace

***Investigate Anomalies –Goal Driven Adaptable Software Architecture  
(SER001)***



Visualisation provided  
by Virtual Battlespace

*Investigate Anomalies – close-up of anomaly*



Visualisation provided  
by Virtual Battlespace

***Investigate Anomalies – autonomous vehicle arrived at location of anomaly***



Visualisation provided  
by Virtual Battlespace

***Goal Achieved - photograph taken at location of anomaly***

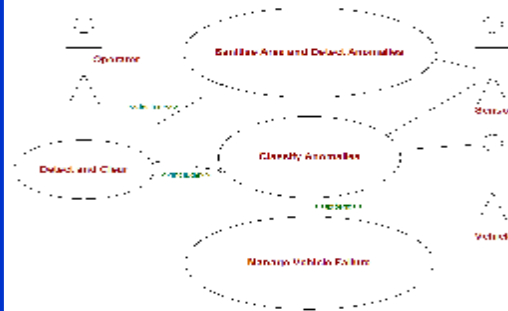


Visualisation provided  
by Virtual Battlespace

# Systems Engineering using UML

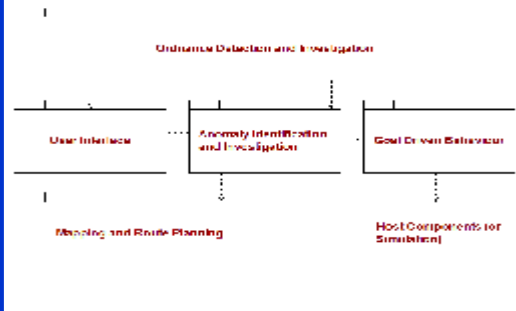
## 1. Capture Requirements

### System: Use Cases



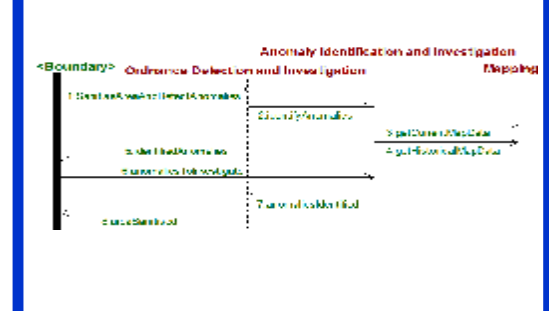
## 2. Partition into Domains

### System: Domain Model

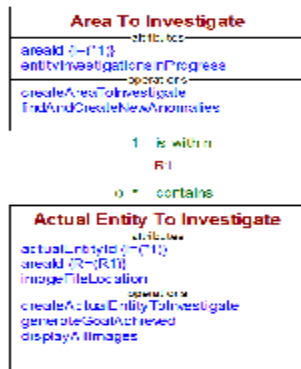


## 3. Define Domain Interfaces

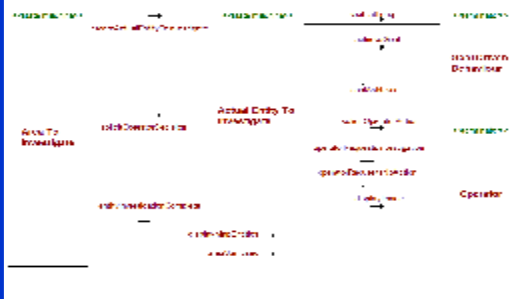
### Use Case: Sequence Diagram



### Domain: Class Model



### Domain: Interaction Diagram



### Class: State Model



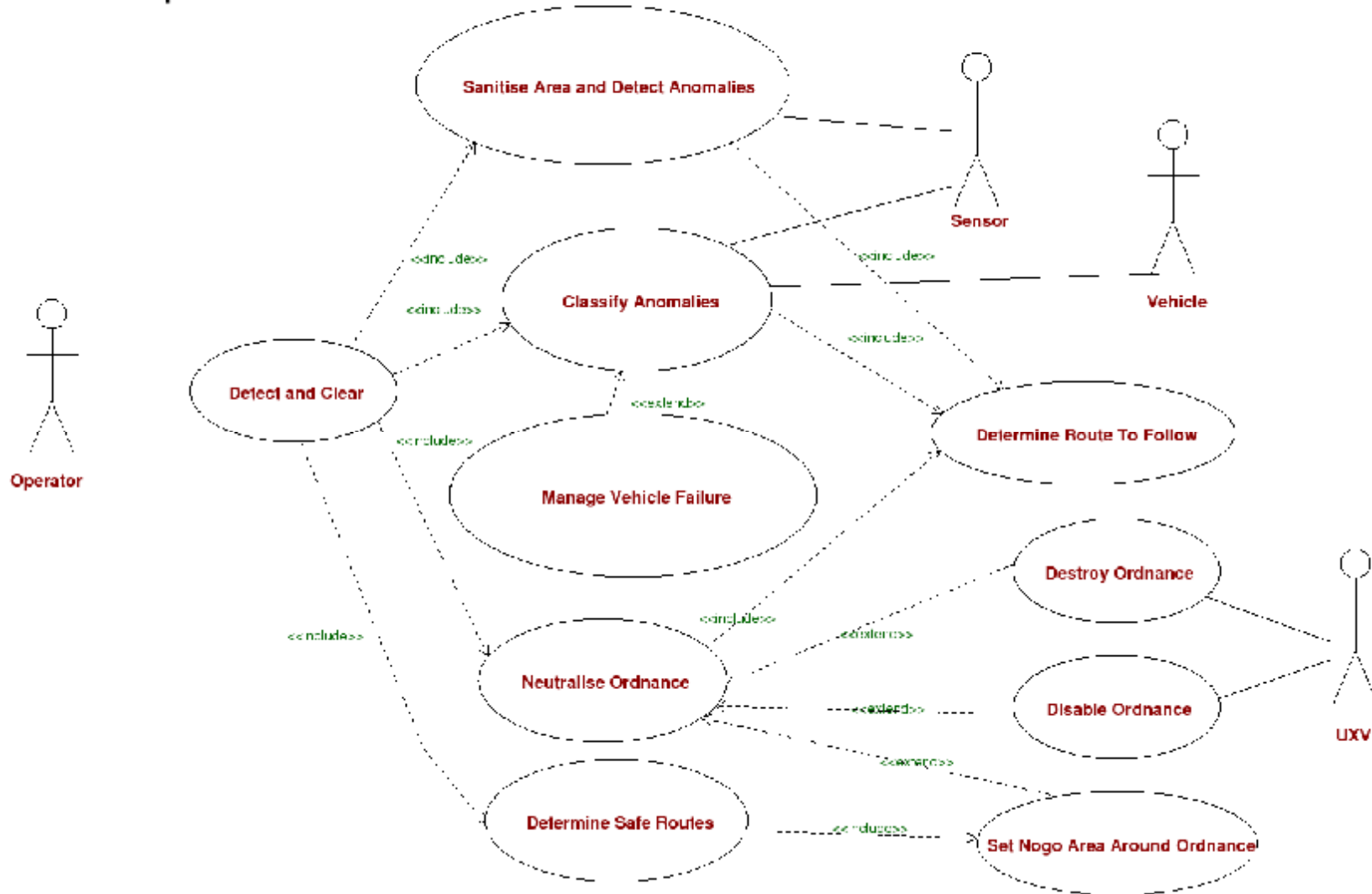
## 4. Specify Classes

## 5. Define Class Interfaces

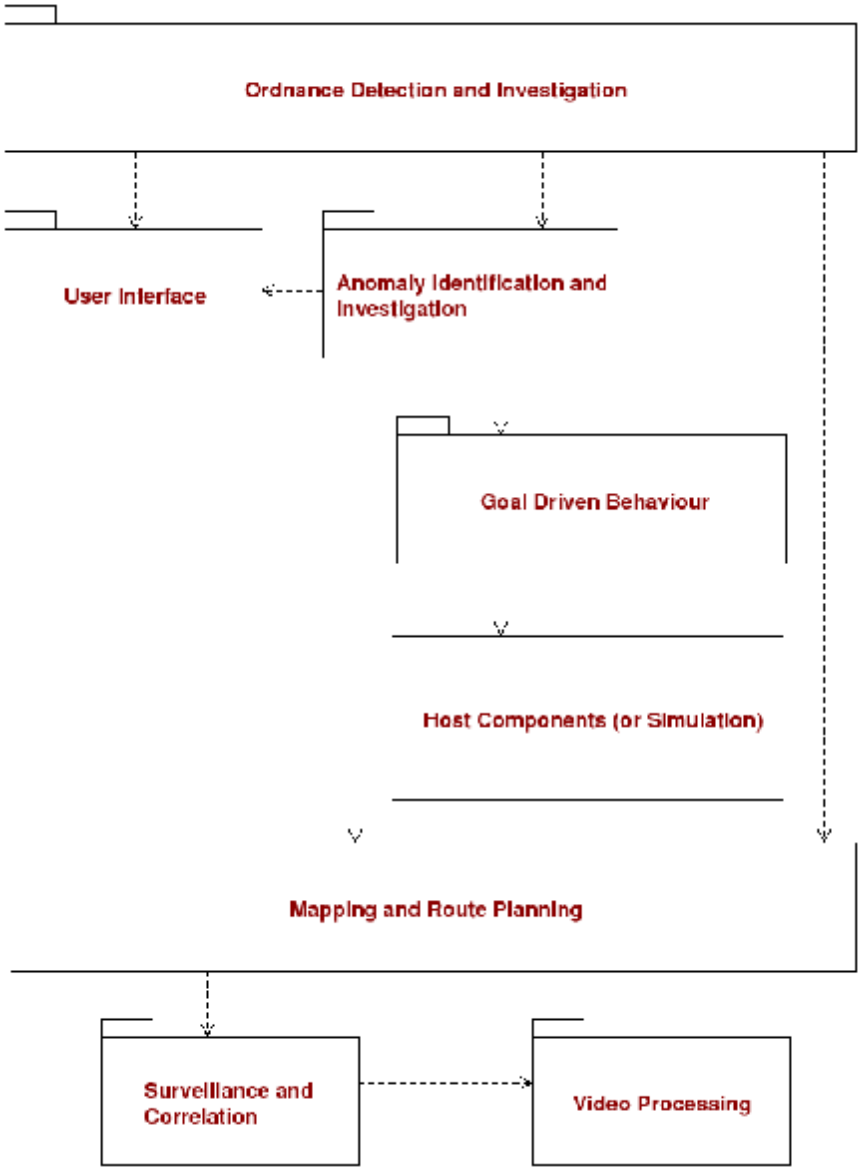
## 6. Specify Behavior

## Use Case Diagram for the System

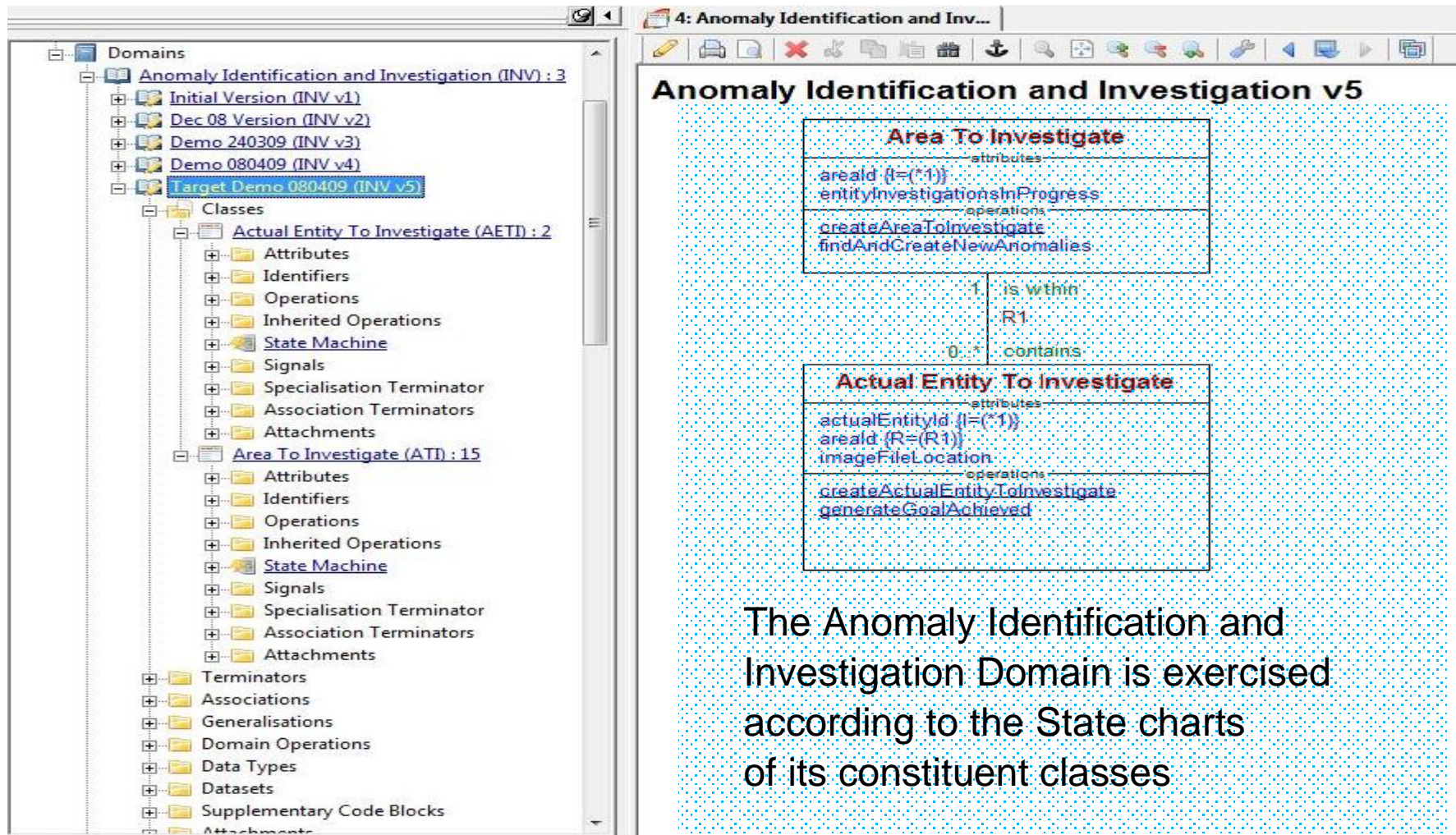
### L9 - Mine & Explosive Ordnance Detection and Clearance



**Domain Diagram**

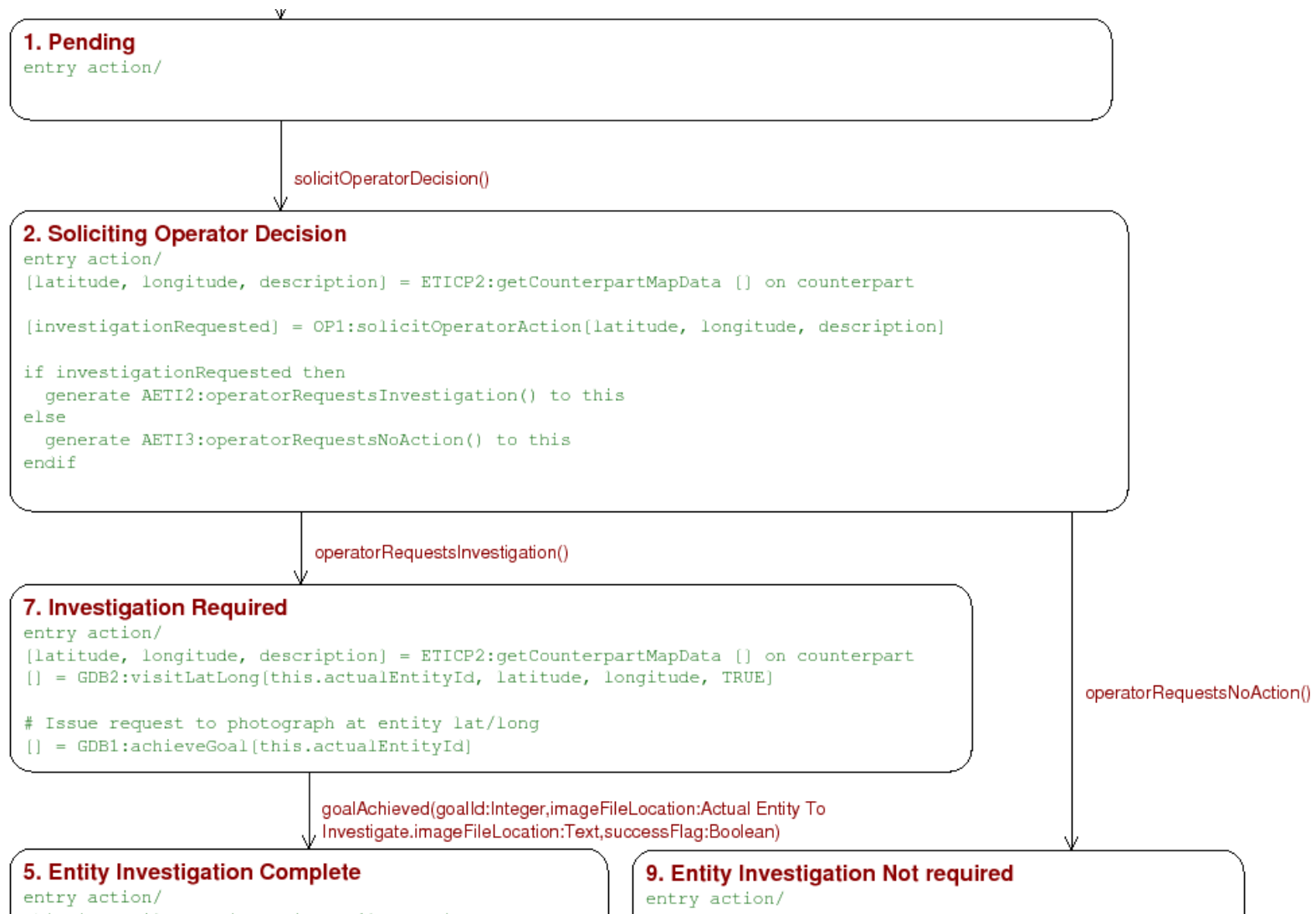


## Anomaly Identification and Investigation Domain



The Anomaly Identification and Investigation Domain is exercised according to the State charts of its constituent classes

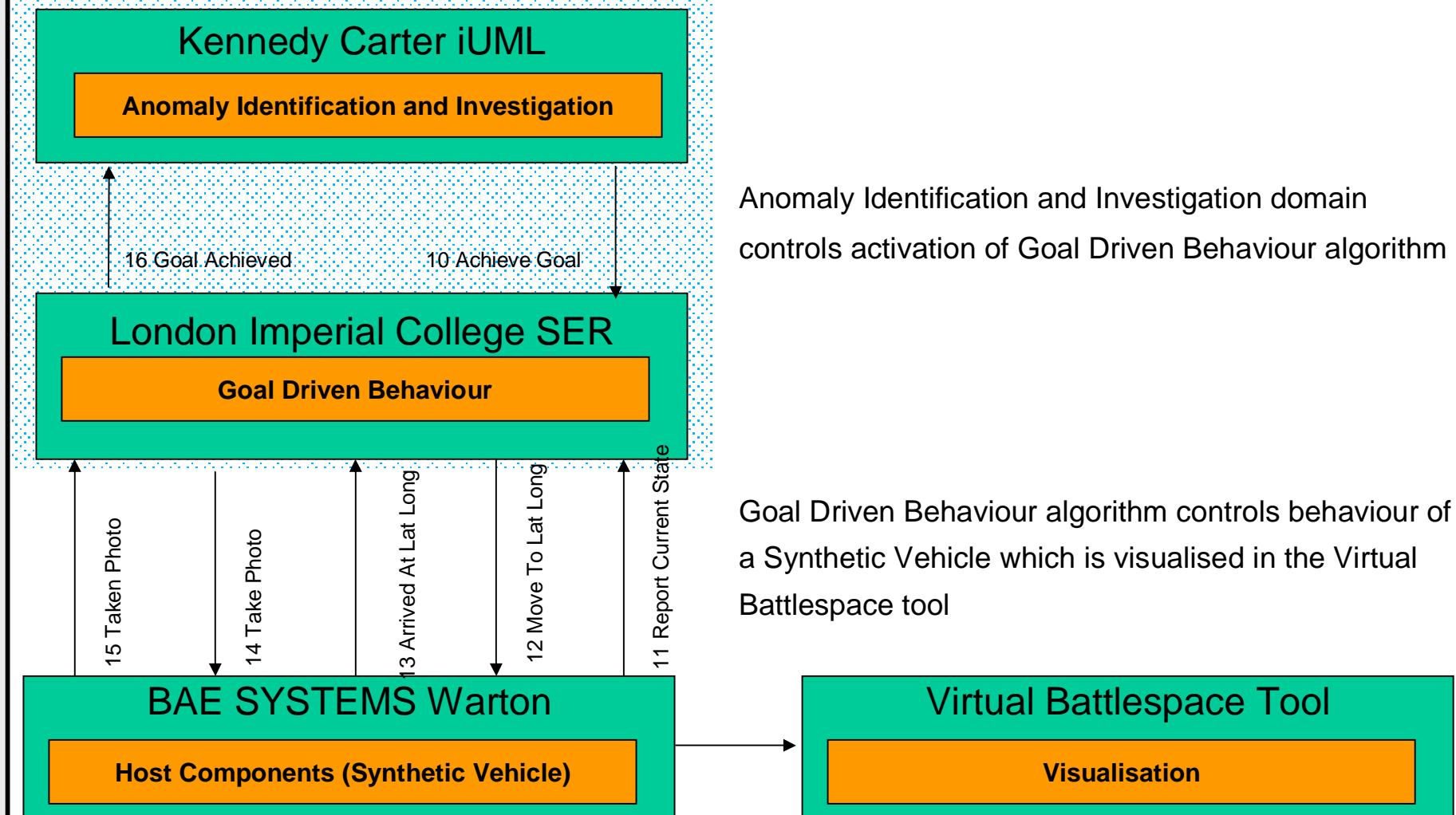
## State Chart for 'Actual Entity to Investigate' Class



## *Executing the Model with xUML*

- Simulation of an xUML domain is achieved by translating the model into code, compiling it and then executing it within a simulation environment.
- Executes the action specification language (ASL) within the classes.
- The simulation enables the domain behaviour to be verified.
- Generates a console for monitoring states and information

## Sanitise Area and Detect Anomalies - communications



## ***SEI004 - Kennedy Carter iUML Investigation***

### **Research questions:**

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***SEI004 - Kennedy Carter iUML Investigation***

**Technology Demonstration at 14:15 Strathblane Hall :**

**“Using UML to Integrate SEAS DTC Research into an Executable Autonomous System Design with Concept Visualisation”**

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## ***Lessons Learned Exercise***

**The DTC carried out a 'lessons learned' activity under its Systems Engineering Integration area of work**

**A report was produced containing over 200 lessons covering the following areas of the DTC's operation :**

- **Contractual Framework**
- **Organisational, Process and Data Management**
- **Research Programme Planning**
- **Research Programme Execution**
- **Research Programme Outcomes and Exploitation**
- **Stakeholder Management**

## Key Lessons #1 : *Systems Approach to Research*

The systems approach applied by the SEAS DTC to technology integration maximises the chance of successful application of low maturity research :

- Greatest chance for focusing of innovative technology on real military needs
- Encourages greater systems thinking amongst the research community
- The use of vignettes and challenges to provide a relevant defence context
- Functional building blocks - 'mini-threads' and 'threads'
- Demonstrations and experiments at all levels of work ground the research in reality and provide challenge to the technology outcomes



## Key Lessons #2 : *Building a Research Community*

**The SEAS DTC has established a strong technical community within its area of interest, but this has taken consistent effort over a period of years:**

- Cross-sector knowledge and understanding of capabilities and skills
- Pre-existing relationships exploited and strengthened
- Links between disciplines and institutions that did not exist before
- It takes time to establish relationships and build trust
- Full understanding of the federated research themes and directions not present at the outset - developed through interaction and dialogue



## Key Lessons #3 : *Decision-making*

**Short decision-making lines and minimal bureaucracy are important to the SEAS DTC**

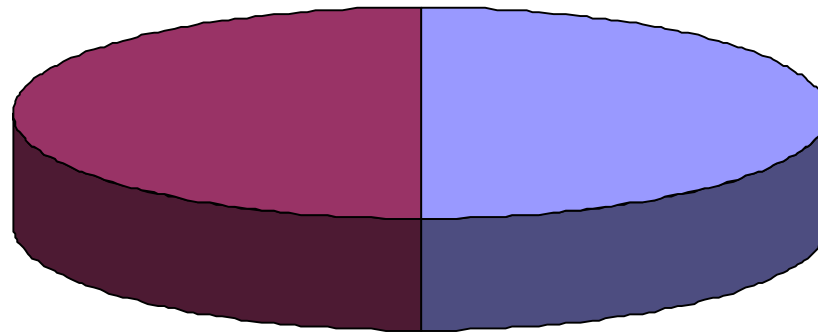
- Focused decision-making within a small management team helps
- ... although a challenge for people with 'part-time' DTC roles
- The role of an independent Technical Director is important



## Key Lessons #4 : *Contribution in Kind*

The SEAS DTC's approach to Contribution in Kind (CiK) has maximised the value of the industrial consortium's contribution to the overall DTC programme

- Mutually agreed principles and rules between MoD and industry
- Integration of CiK across all areas of research programme
- Provide as much visibility as possible of CiK within the consortium
- Jointly run process for presentation and assessment of CiK



■ Core MoD Funding  
■ Contribution in Kind

## Key Lessons #5 : *Outcomes and Exploitation*

**SEAS DTC outcomes can be exploited through many routes and at many levels**

- Many potential routes to exploitation, some planned, others more ad-hoc
- Exploitation of early stage concepts and ideas as well as technologies
- Early stakeholder engagement and ongoing communication vital
- Bridging the gap between low maturity 'proof of concept' research and pull-through to programmes remains a challenge



## Key Lessons #6 : *MoD Advice to the DTC*

The SEAS DTC's relationship with its Dstl advisory team has been a strength, but could now be developed further

- 'Mirrored' Dstl advice team works well - valuable advice and guidance, but freedom of DTC decision-making retained
- More dynamic involvement recommended
- Increased direct military advice



## Key Lessons #7 : *Risky Areas / Difficult Problems*

The SEAS DTC's approach to risky technology areas balances a willingness to attempt hard problems with a pragmatic approach to finding workable ways forward

- Innovation Fund highly beneficial
- Parallel approaches to difficult areas increases the chances of overall success



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## ***Programme Expectations***

**Looking ahead to the expected overall outcomes from the DTC in the timescale of its current contract :**

- An enduring research capability in autonomous (and semi-autonomous) systems for us and others to build on
- Evidence of improved understanding of the required interaction of humans with autonomous systems
- A portfolio of technological advances and systems engineering to be applied to autonomous systems
- A systems capability to evaluate technologies critical to autonomous systems
- A systems capability to enable the construction and evaluation of prototype autonomous systems
- Evidence of having successfully demonstrated and evaluated at least one prototype autonomous system
- An autonomous systems engineering handbook
- Roadmaps linking technologies through enabled capabilities to military benefit
- A lessons learned document



# SEAS DTC

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[www.seasdtc.com](http://www.seasdtc.com)

