

SEAS DTC

SEAS DTC Capability Challenge Descriptions

January 2010

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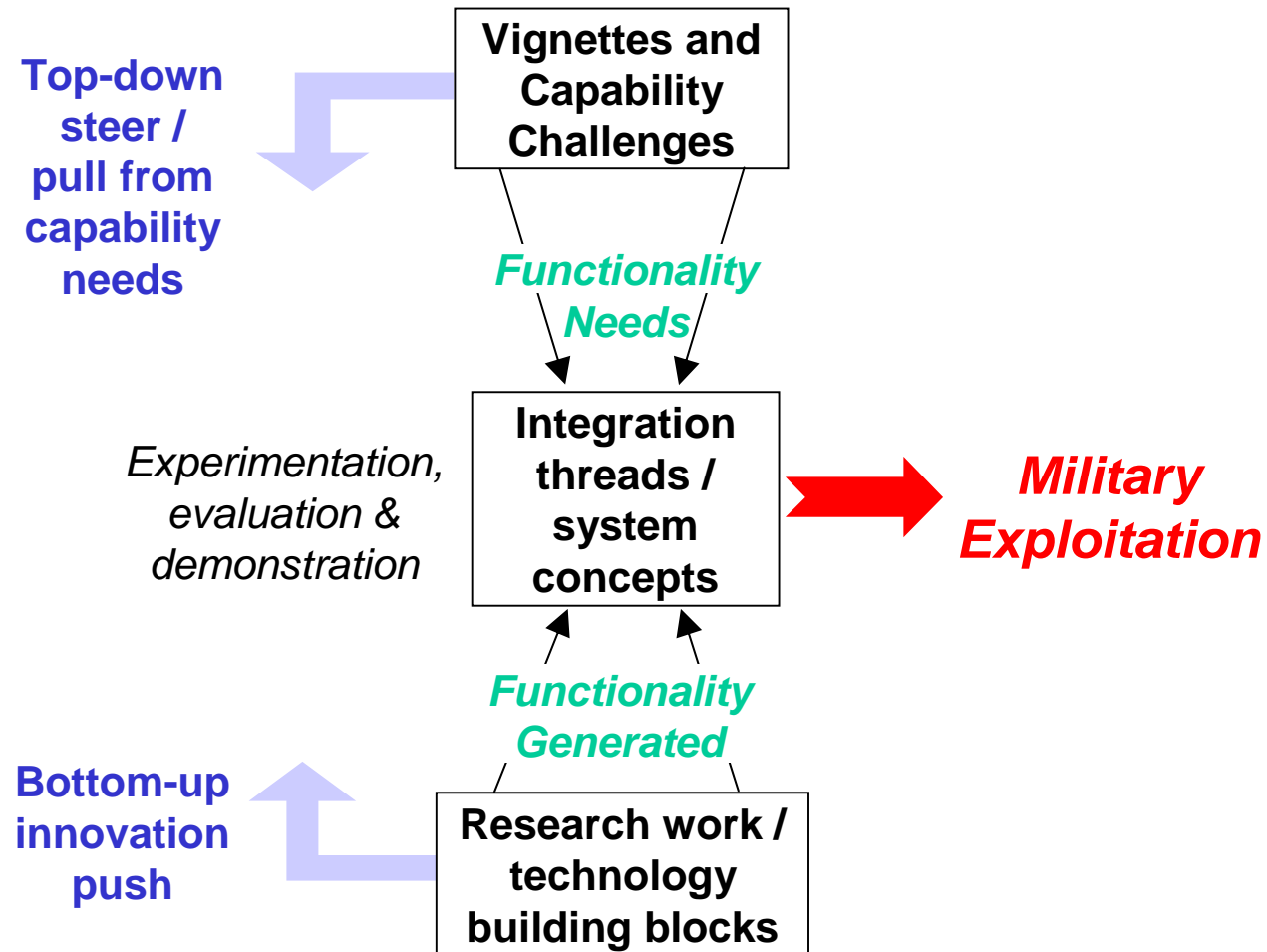
Changes in this Issue

- New challenge – **A6 UAV Recovery to an Unprepared Site** has been added.
- The following challenges have been deleted since the previous issue:
 - **L4 Base protection against projectiles** – this is being addressed by other MoD research.
 - **L11 Battlefield engineering (digging)** - this is being addressed by other MoD research.
 - **S8 UUV Robustness (Currents & Tides)** – merged into **S3 Small UXV Operation in Rough Seas**.
 - Additionally **S5a Logistics supply by sea** and **S5b Resupply of warships at sea** have been merged to form a revised challenge - **S5 Logistics Supply by Sea**.
- Similar challenges exist across domains and it is thought that the solution in one domain may be applicable in others. Three such sets are identified:
 - Vehicle control when operating in difficult environments – A1, L7 & S3
 - Vehicle launch and recovery in difficult environments – A2, A4, L2 & S11
 - Vehicle endurance/self-sufficiency - A3, L13 & S9
- Slide added showing an overview of the links between the Capability Challenges, the DTC research and potential exploitation.

Acronyms

- A/SA autonomous / semi-autonomous
- ADU air defence unit
- DAS defensive aid suite
- DoF degree of freedom
- EOD explosive ordnance disposal
- FIAC fast in-shore attack craft
- GW guided weapon
- HITL human in the loop
- IED improvised explosive device
- IFF identification friend or foe
- JSF/JCA Joint Strike Fighter/Joint Combat Aircraft
- M-UXV Maritime-UXV
- MCM mine counter-measures
- NBC nuclear, biological & chemical
- NEC network enabled capability
- ROE Rules of Engagement
- STOVL short take-off & vertical landing
- UAV unmanned air vehicle
- UGV unmanned ground vehicle
- USV unmanned surface vessel
- UUV unmanned underwater vessel
- UXV generic unmanned vehicle
- VTOL vertical take-off & landing

The SEAS DTC's Exploitation Model



Military Capability Challenges

- **Using 'capability challenges' to capture a view of military need and to stimulate DTC research**
- **A 'capability challenge' is a capability that is required to enable a military task to be performed.**
- **The challenges have been grouped by domain for convenience - however, some are cross-domain.**
- **The challenges vary in scope, some being broad, others more specific.**
- **In some cases, the military task can be performed today, but perhaps inefficiently or only by putting lives at risk. The challenge in these cases is to develop autonomous systems to reduce the risk to humans or improve operating efficiency.**
- **There is a continual drive to reduce costs of procuring and operating equipment. Autonomous systems may improve the operating efficiency of current and future systems to give cost savings by, for example, reducing (specialist) manpower requirements.**

Capability Challenge List – January 2010

Air		Land		Sea	
A1	Urban Robustness (gusting around buildings)	L1a	Autonomous Surveillance	S1	Littoral Surveillance and Interception
A2	Operation of UAV from Maritime Platform	L1b	Autonomous Reconnaissance	S2	Mine Countermeasures
A3	Airborne endurance	L2	Medium UAV Operation from Ground Vehicle	S3	Small UXV Operation in Rough Seas
A4	Operation of UAV from Aircraft	L3	Curfew Keeper / Patrol	S4	Remote Acoustic / ASW Sensing
A5a	Strategic Logistics Supply by Air	L5	Logistics Supply by Land	S5	Logistics Supply by Sea
A5b	Tactical Logistics Supply by Air	L6	Evacuation of Wounded	S6	UUV Communications Relay
A6	UAV Recovery to an Unprepared Site	L7	Obstacle Crossing & Route Proving	S7	Protection of Merchant Shipping
		L8	Building & Tunnel Exploration	S9	UUV Self Sufficiency
General / Joint		L9	Mine & Explosive Ordnance Detection and Clearance	S10	Dealing with Man-made Obstacles
J1	UXV Autonomy & Responsivity	L10	Checkpoint Monitoring	S11	Recovery of UUV and USV to Ships
J2	Tactical replanning for group of UXVs	L12	Battlefield Engineering - Surface Repair		
J3	UXV training on the job	L13	Ground Vehicle Endurance		
J4	UXV intuitive behaviour				

A1 Urban Robustness (gusting around buildings)

- Fixed wing UAVs flying between tall buildings in urban environment, small UAVs hovering close to buildings, small hovercraft close to buildings or large ships - all tend to fail because of turbulence / gusting overwhelming the control system at wind speeds >10kts. Similar conditions will exist near ships due to airwake turbulence caused by ship superstructure.
- Challenge is to ensure can maintain complete control, keep on station or maintain transit, in presence of "reasonable" turbulence levels with low/zero operator workload.
- General approaches could include predicting/sensing danger areas, fast-acting effective active compensation for detected platform perturbations, system design for low susceptibility to gusts.
- A/SA systems could give increased operational envelope.
- This challenge concerns operating in difficult environments, similar ones exist for UGVs due to various obstacles, and for USVs, UUVs etc when in tidal/flowing waters near underwater obstructions, quays/piers etc. in other domains, see L7 & S3.

A2 Operation of UAV from Maritime Platform (recovery to platforms with heave and roll)

- Launch and recovery requires coping with 6DoF motion of both ship and UAV in the presence of fluctuating atmospheric environment caused by turbulence and by the ship's bulk modifying normal wind flow. Operation of UAV could be from both aircraft carriers and ships without flight decks e.g. destroyers, fleet auxiliaries, ships taken up from trade etc. Large STOVL aircraft are excluded as part of existing JSF/JCA Programme.
- Challenge is to enable routine UAV operations from any ship without requiring a highly trained operator. There are major safety / confidence issues to be resolved; a ship's captain may not trust UAVs to land autonomously without damaging ship; ship's crew could damage the UAV during manual landing.
- General approaches could include mutual sensing and intimate guidance between 2 moving objects.
- Benefit of SA/A could be wider usage of UAVs on carrier and other ships, reduced training, wider operational envelope.
- This challenge concerns launch and recovery in difficult conditions, there are other similar ones, see A4, L2 & S11.

A3 Airborne Endurance

- Lack of endurance is a major problem for all UXVs (see also L13 & S9)
- Challenge is to increase endurance so it is no longer an operational issue over operational durations of hours/days. Note that it is difficult to specify target values for endurance. (Challenge could be extended to weeks/months rather than hours/days.)
- General approaches include design to need/use less energy, and SA/A systems to enable replenishment of energy stores. (Note: Lighter than air craft (balloons, airships) do not use power for support.)
- Possible approaches could include:
 - SA/A system that seeks and maximises energy replacement, via say soaring and/or converting height to electrical power using diving and a generator.
 - SA/A systems with energy recharging/refuelling without operator workload
- Measures of effectiveness are UXV availability, and increased endurance per kg of energy stored at take-off.

A4 Operation of UAV from Aircraft (launch and recovery)

- Transporting small UAVs on a larger UAV/manned platform could enable small UAVs to be deployed effectively at very long range, with the larger UAV remaining at altitude and providing a data processing / relay station. Recovery is a much more difficult problem than launch.
- Problem has similarities to A2 in requiring control/interaction of two platforms where both have 6DoF, are likely to be of different sizes and dynamic properties, and are operating in a turbulent environment. The mother aircraft could be a large transport aircraft, an airship, large UAV or seaplane.
- The challenge is to find robust means of recovering UAVs to manned or unmanned aircraft.
- Approaches could include capture of UAV on a controlled drogue then winching UAV into body of mother-ship, control of UAV dynamics from the mother-ship during UAV landing on mother ship.
- Autonomous recovery systems would reduce/remove operator workload and eliminate HITL latency problems. Benefit is increased operational stand off.
- This challenge concerns launch and recovery in difficult conditions, there are other similar ones, see A2, L2 & S11.

A5a Strategic Logistics Supply by Air

- Lift of bulk quantities of military stores from home bases to a few destinations in theatre. Could include supply of provisions to civilians in peace support or humanitarian aid situations. Potential strategic lift platforms could include airships and large transport aircraft.
- Challenge is to transport bulk stores across large distances to a *prepared* location and without hindrance from operator fatigue or working-time limits. Safety issues include deconfliction with other logistics carriers and other air users (manned and unmanned) both in the air and on the ground (link to ASTRAEA work).
- A/SA systems could enable:
 - More tonne/miles per day 24/7/365
 - Delivery in marginal weather conditions (that would not be allowed with manned aircraft).

A5b Tactical Logistics Supply by Air

- Lift of smaller parcels of stores over inter-theatre distances to a large number of *unprepared* destinations. Potential delivery platforms could include small airships, helicopters, tilt-wing aircraft, parafoil (powered and un-powered) and hovercraft.
- Challenge is to deliver to the right places when required by a means that ensures the stores arrive undamaged and are able to be used without delays caused by need for post-delivery inspection or preparation. Ultimately a guaranteed “soft-ride” could reduce environmental requirements on stores and stores packaging. As delivery is in theatre the security of supply is also an issue.
- SA/A systems could enable:
 - 24/7/365 logistics without manpower fatigue or work-time limitations
 - No combat cover required
 - Reduction in ‘shock’ requirements for air-dropped equipment
 - Reduced packaging requirements (more payload/ tonne).

A6 UAV Recovery to an Unprepared Site

- Air vehicles quite often have to recover/land at a site other than that planned at the start of the mission. This can be due to a variety of reasons such as technical failure, weather, enemy action, etc. In most cases alternative prepared recovery sites will have been identified during mission planning.
- This challenge concerns an emergency situation with recovery to an unprepared site which has no landing aids and has not previously been surveyed.
- The UAV has to locate a suitable landing site, determine there are no obstacles to prevent recovery and then conduct a safe landing.
- The advantages of such a system are less attrition. Also such an autonomous recovery systems could help to reduce/remove operator workload during normal operations.

L1a Autonomous Surveillance

- Surveillance is defined here as continuous observation of an area, perimeter or fixed point. (as opposed to L1b reconnaissance which is a dedicated activity for a period of time, of a battlefield to seek out specific information, e.g. opposing force's disposition). System could be static, or mobile. Has similarities to L3 Patrol / Curfew Keeping.
- Challenge is to provide an unattended surveillance system in which endurance is not an issue, that can operate in all reasonable weather conditions, can sense changes in the scene, determine their relevance, and transmit only the important data back to base. Sensing could involve any part of the electromagnetic or acoustic spectrum, and NBC sensing.
- Challenge could be broadened to include optimising position (balancing security and better access to relevant data), planning of movement and optimising search patterns.
- Autonomous system benefits
 - a) minimise human attention needs, by only alerting if significant information is sensed
 - b) limited transmission bandwidths and data storage requirements.

L1b Autonomous Reconnaissance

- Reconnaissance is a very taxing, complex and hazardous task and involves gathering data on e.g. enemy dispositions, ideally without disclosing that you are gathering that data.
- Challenge is to provide a reconnaissance system in which endurance is not an issue, that can operate in all reasonable weather conditions, can move and navigate around the battlefield, is covert and can determine the optimum routes to locations to maximise terrain screening and gain data, optimise search patterns, and transmit an assessment back to base.
- Approaches could include swarms of similar vehicles; a vehicle that deploys fixed surveillance sensors and monitors their outputs from a hide; doppelgangers (e.g. farm tractor) carrying sensors. A specific case is a 'buddy-boy' UGV which operates just in front (<50m) of manned vehicles or troops to provide warnings of threats such as IEDs, mines, snipers etc. Challenge L9 Mine & Explosive Ordnance ... has some similar requirements.
- A/SA systems could reduce exposure of manned reconnaissance squads and be available for a larger proportion of the day.
- Effectiveness is the relationship between the area examined to the observability by the enemy

L2 Medium UAV Operation from Ground Vehicle

- Has some similarities to A2, A4 and S11. Added complications are likelihood of increased turbulence and gusting levels close to the ground, the motion of the ground vehicle being constrained by terrain, hazard to UAV from power lines, trees, poles & ground features - including other vehicles/ pedestrians.
- Challenge is to launch and recover UAVs to a ground vehicle (manned or unmanned) operating on ordinary roads without requiring HITL intervention.
- Approaches could include VTOL UAV landing on a stationary or moving vehicle (or alongside and being lifted into the vehicle); fixed wing UAV landing on moving vehicle; UAV flying over vehicle being grabbed and pulled down onto vehicle; intimate control of UAV / ground vehicle as a coupled system. Difficulties could include the ground vehicle needing to sense and predict its future route during recovery.
- A/SA systems could enable medium UAV recovery to vehicle without need for large dedicated UAV support troop i.e.an organic asset at Company level
- Also the prospect of recovery of unused Loitering Munitions.

L3 Curfew Keeper / Patrol

- Challenge is to provide a AS/A system that will overtly patrol an area or perimeter, deter curfew violation, sense violations when they occur and take appropriate action. Has similarities to L1a Autonomous Surveillance.
- Curfew keeper / patrol could be a UGV or a mixture of UAVs and UGVs.
- Many issues, endurance, mobility, ability to sense the whole urban environment (buildings, vehicles, people, animals), ability to communicate within a urban environment, provision of an IFF, minimisation of false alarms against wild/stray animals, (apprehending curfew breaker), lethal / non-lethal enforcement, survivability of vehicle, safety of legitimate civilian curfew breakers e.g. emergency civilian services (doctors / fire brigade / ambulance).
- A SA/A curfew keeper / patrol would relieve the boredom and danger of human curfew keeping. Reduced patrolling / curfew keeping man-hours could be measure of benefit.

L5 Logistics Supply by Land

- Covers a wide range of logistics needs from movement of large quantities of stores from point of entry into theatre to the staging areas; resupply of a battle group or infantry squad; to provisions supply to civilians in peace support humanitarian aid situations. Platforms could include trucks and tankers for heavy lift, Supacats, quad-bikes and small hovercraft for smaller scale local resupply.
- Challenge is to provide a practical SA/A logistics system that can get the stores to the right place at the right time safely and securely (given it is likely to operate in a potentially or real war zone). One approach could be a robotic follower. Another is to provide air cover for a manned convoy with a UAV keeping station with the convoy.
- SA/A systems could enable
 - reduced danger to drivers when supplying in threatened locations
 - reduction in logistics manpower.

L6 Evacuation of Wounded

- Extremely hazardous undertaking as draws fire (lots of medals won for rescuing injured).
- Challenges include providing a system to remotely ascertain degree of injury, possibly getting a medic safely to the wounded (transport within armoured stretcher/container?), providing self-help within container if wounded capable of entering it, lifting incapable wounded into container without causing further injury, transporting wounded safely and quickly to rear area.
- A manned vehicle that could re-trace its route while the driver attends to the casualty could be a partial solution.
- This challenge could also include the recovery of injured or uninjured personnel from a disabled vehicle or plane, recovery of trapped personnel (military or civilian) in an urban siege situation etc.
- SA/A systems could enable recovery of wounded without risking further casualties, reduction in number of stretcher party personnel.

L7 Obstacle Crossing & Route Proving

- Challenge is to provide an autonomous system that enables a UGV to determine, clear and drive a workable route to suit a given operational need. The system could also provide a route planning aid for a manned vehicle.
- Route proving involves identifying a viable route for a given purpose and then transiting the route to show there are no obstacles (or clear them if necessary). Involves sensing the state of the going at a distance, mapping the going, selecting a route to avoid major obstacles, navigating to reach the desired destination. Function could be provided by a combination of UAV/UGVs operating cooperatively.
- Obstacles could include mud, sand, shrubs/trees, crops, water, kerbs, steep slopes, rubble/boulders, barbed wire, vehicles, fallen trees, roadblocks, weak roads/bridges etc.
- Three aspects – providing :
 - Drive systems to enable obstacles to be crossed (lower priority)
 - Systems to find and select routes to enable proposed traffic use that avoid having to negotiate the worst of the obstacles (higher priority)
 - Ability to clear obstacles (where necessary)
- Autonomy could reduce time needed to establish the route compared to manned systems, and allow reduced manpower needs.
- This challenge concerns operating in difficult environments, similar ones exist in other domains, see A1 & S3.

L8 Building & Tunnel Exploration

- “Tunnels” include road/rail tunnels, caves, sewers – and buildings could have stairs, cellars and/or lofts, be factories, shops or offices. Main problem with current building explorers is that they are too slow and their use seriously slows operational tempo.
- Need to sense, map and interpret the whole environment {including physical boundaries, presence of hazards (including human), NBC mapping, booby trap sensing etc}, determining areas requiring further investigation, determining optimum search strategy, and recording and communicating processed data picture, thereby avoiding the risk to personnel of entering an unknown potentially hazardous situation while maintaining operational tempo.
- Challenge is for a SA/A system to provide a comprehensive “picture” of the interior of enclosed spaces in minutes not hours.
- Benefit measured in terms of time needed to survey building compared with current systems, giving improved operational tempo.

L9 Mine & Explosive Ordnance Detection and Clearance

- Includes buried mines, discarded & unexploded but fired munitions (including those buried due to their kinetic energy), improvised explosive devices, booby-traps etc.
- A main task for a SA/A system would be the marking of mine positions and safe routes through minefields.
- The greater challenge is for a SA/A system to detect the device, determine its characteristics, decide whether it can be removed safely or must be disposed of in situ, and then effect the excavation / shielding / disruption / disposing of the device, while ideally maintaining the own system's survivability.
- A swarm of cooperative devices (perhaps with different capabilities) could be let loose to sweep and clear an area for civilian use following a conflict.
- The benefit of a SA/A system would be that it could clear a route or minefield 24/7 without danger or fatigue to personnel.
- Challenge L1b refers to a specific example of a UGV, 'buddy-boy', operating just in front of manned vehicles or troops to provide threat warnings.

L10 Checkpoint Monitoring

- Soldiers manning checkpoints are vulnerable as they are relatively static and have to approach and search vehicles / people to check them out.
- Challenge is to replace manual checkpoints by A/SA monitored checkpoints so that personnel are not as immediately vulnerable to attack (by suicide bombers / gunmen etc).
- Subsidiary challenges include ability to set up a checkpoint, ability to sense traces of explosives (by chemical sniffing), guns (terahertz radar), face recognition, automatic number plate / vehicle recognition / tracking etc, plus ability to process data and communicate to base station.
- Ability to assess people's behaviour to detect suspicious behaviour is another challenge.
- A further challenge would be to autonomously search people / animals and under/inside cars & vehicles.
- Benefits of a SA/A system could include higher detection and/or lower false alarm rates, hence reduced soldier losses.

L12 Battlefield Engineering – Surface Repair

- Road and runway surface repair could entail clearing vehicle debris, assessing damage and repairing craters left by bombs etc (in the presence of time delay and other mines), perhaps while under fire.
- Challenge is to provide a A/SA system capable of restoring a damaged surface for use in a short time without danger to personnel.
- This could involve the use of a range of cooperative unmanned diggers, bulldozers, trucks, cranes etc. The system must determine the operational state of the surface, before and during the repair.
- Benefits of A/SA are to reopen surfaces 24/7 without driver fatigue and with reduced personnel danger.

L13 Ground Vehicle Endurance

- Lack of endurance is a major problem for all UXVs (see also A3 & S9)
- Challenge is to increase endurance of UGVs so that endurance is no longer an operational issue over operations of hours/days. (Challenge could be extended to weeks/months).
- General approaches include design of UGV to need/use less energy, or SA/A systems to enable replenishment of energy stores.
- Autonomous refuelling with a tanker UGV is one option. Other options could be for autonomous top-up at a petrol station, or plug into domestic or street power lines etc.
- Improvements in reliability, self monitoring and recovery will be needed to complement significant increases in endurance.
- Benefit could be measured as percentage increase in endurance over a 'one shot' system.

S1 Littoral Surveillance and Interception

- Need to defend ones own littoral including ports and shipping, and survey others assets by maintaining surveillance over an area of water – including estuaries, ports, coastal defence, fixed installations, fiords, around islands, from a short distance inland to the edge of the continental shelf - and if an unidentified object is detected a speedily response is supplied.
- Challenge is to obey rules of the sea in congested waters and not present an inappropriate threat to other shipping, plus the ability to operate in poor weather and seas. And to act on information from anyone in the battlespace.
- Platforms could be any type of unmanned vehicle (UXV) eg. USV, UUV, amphibian, airship or a seaplane (or a combination).
- SA/A systems could avoid the burden and risk of manned surveillance of other's assets. Benefit could be measured in terms of a reduction in manning level.

S2 Mine Countermeasures

- Conventionally a surface ship searches a volume of sea to detect possible mine-like objects, then a diver (or UUV) is sent down to the object, determines its identity (UUV sends video via a fibre link to the surface ship for analysis), followed by mine disposal. Often this involves a charge being placed on the mine by the diver or the UUV detonating its onboard explosive device and thereby destroying itself.
- The challenge is to provide a system that can deploy countermeasures, which detect, locate, classify, identify and dispose of mine like targets, out of the immediate control of a manned parent platform.
- A/SA systems could enable 24/7 MCM without risk to manned naval ships.
- Benefit of SA/A system could be measured in terms of time to clear a volume of sea from a safe zone and confidence in detecting all targets.

S3 Small UXV Operation in Rough Seas

- Turbulent seas hinder maritime UXV missions.
- Challenge A: Surface sea keeping is to enable the UUV/USV to sense the surrounding local environment (wave structure, currents, winds etc) at a sufficient distance that the UUV/USV has time to react / manoeuvre and compensate for the disturbances before they impact, thereby enabling its survival, course/station maintenance, and mission completion.
- Challenge B: Underwater sea keeping - Maintain position or course in dynamic currents produced from manmade (pylons) and natural (rocks / beach) obstacles.
- Benefit could be measured as an increase in operational envelope from the presently limits of sea state 1-2.
- This challenge concerns operating in difficult environments, similar ones exist in other domains, see A1 & L7.

S4 Remote Acoustic / ASW Sensing

- ASW includes use of manned aircraft/helicopters to drop sensors and helicopters to hover and dunk sensors.
- The challenge is to replace the manned helicopter/aircraft by (packs of) UXVs operating cooperatively. Seaplanes, airships or helicopters could alight on the sea surface in a pattern to dunk recoverable sensors, UAVs or UUVs could drop (non-recoverable) sensors that transmit data to UAV / base for processing.
- The challenge includes the autonomous processing of the received data on the UAV, assessing its significance, the intelligent relocation of the pack to improve fix on detected targets, communications with base etc.
- A/SA systems could augment the current capability, operate 24/7 without need for trained pilots (and their limitations due to fatigue etc).
- Benefit measured in terms of reduction in personnel.

S5 Logistics Supply by Sea

- Offload of shipping is reliant on adequate port facilities but these cannot be guaranteed for a variety of reasons –
 - damage,
 - draught,
 - coalition / commercial priorities,
 - explosive licenses, etc.
- The challenge is to offload roll-on/roll-off ferries and container ships through austere ports and possibly even over a beach. In particular to provide a system to unload ships without the use of existing port facilities. Or the ability to transfer a container from a commercially chartered ship to the shore or on to lighterage in Sea State 2.
- The benefit will be faster offload of shipping enabling faster build up of force and eliminating the Sea Port of Disembarkation becoming a bottleneck in the deployment.

S6 UUV Communications Relay

- Subsurface communications are challenging due to the high impedance of RF communications and by the effects of salinity and temperature variations causing channelling and dead zones for acoustic communications.
- Challenge is for the UUV to autonomously establish and reach workable positions that enables effective communication within the sea to other UUVs, to surface vessels and to airborne assets.
- Benefit is improved communications robustness allowing the deployment of an effective NEC infrastructure underwater.
- Enabling technologies to improve connectivity and communication paths is also part of the challenge.

S7 Protection of Merchant Shipping

- Merchant shipping may be required to operate in potentially dangerous areas. Vessels in these areas may encounter threats from suicide boats, FIAC, GW, mines, torpedoes or divers; with the intent of hijacking, inflicting damage or sinking.
- The challenge is to under take vessel protection activities (deter, detect, decide threat, decide intent, and respond.) autonomously with a maritime UXV (M-UXV).
- Detection of threat may be from UXVs, ship's sensors or shore based facility.
- Responses by the M-UXVs can vary from simple communication to armed response. Vehicles may be deployed from the ship, shore or on a naval fires vessel. Operation of a weapon system on a merchant ship by non-military personnel will have legal implications.
- Benefits will be measured in the reduction of manpower, logistical support and in the avoidance of specialist personnel or equipment on the merchant ship or other asset.

S9 UUV Self Sufficiency

- The use of unmanned systems can reduce the risk to the UK Forces during dangerous missions. Increasing the self sufficiency of these vehicles enables an increase in operational stand off distances, an increase in confidence in the systems and a reduction of manpower requirements.
- The challenge is to extend the distance and duration that unmanned vehicles can operate from a support platform.
- This includes:
 - Energy harvesting
 - Increased survivability
 - Self monitoring / self recovery
 - Increased endurance / autonomous refuelling.
- Benefit could be measured as percentage increase in mission time.

S10 Dealing with Man-made Obstacles

- Seabed and ice ceiling obstacle avoidance systems are available commercially. However systems to avoid man-made objects are less mature. Fishing nets are a prime example.
- The challenge is to operate in presence of nets or other manmade obstacles.
- Regarding fishing nets there are two aspects –
 - sensing / avoiding getting tangled in the first place.
 - dealing with entanglements to either own vessel or to another vessel. Entangled vessels may be a surface ship / USV or a submersible vessel (manned or unmanned).
- If the entangled vessel is another USV then the challenge may be to ensure a different autonomous or semi-autonomous USV equipped with sensors and cutting gear can free the entanglement. If the entangled USV is on its own then the challenge would be to ensure it can extricate itself.

S11 Recovery of UUV and USV to Ships

- Challenge is to accurately control the capture of UUV/ USV during launch and recovery. Surface and subsurface (docking), stationary and underway capture methods are required. The problem becomes more challenging in sea states 3 and above.
- Issue is to control accurately the capture of the UUV/USV.
- The problem of recovering UAVs to ships is covered in A2.
- Benefit could be measured as an increase in the number of vessel types that could employ UUV/USVs.
- This challenge concerns launch and recovery in difficult conditions, there are other similar ones, see A2, A4 & L2.

J1 UXV Autonomy & Responsivity

- Challenge is for UXVs to autonomously:
 - monitor their own subsystems and consumables;
 - manage consumables / their replenishment;
 - recognise subsystem degradations or failures;
 - recognise environmental changes (beneficial or otherwise);
 - communicate changed status to base station
 - and determine the impact of the above and initiate the most appropriate responses, which could include changing / aborting the mission, initiating refuelling, compensating for changes, re-planning route etc.
- Autonomy could provide lower monitoring requirements and hence lower numbers of trained personnel.

J2 Tactical Re-planning for Group of UXVs

- The challenge is for a group of cooperative UXVs (either of same type or a mixture of UAV/UGV/USV/UUV of different characteristics) to autonomously determine among themselves an appropriate way to carry out a mission, whether in response to a commanded change in mission, encountering high value serendipitous targets, as a reaction to the local environmental conditions, or in response to defences that are encountered.
- Challenge involves the group continuously communicating within the group, recognising the characteristics of the available UXVs in the group, recognising any loss of capability (due to loss or absence due to refuelling etc), and determining how they can best continue to operate as a cooperative entity to achieve the mission goals.
- Autonomy could enable human monitoring of the mission, rather than monitoring/commanding of individual UXVs, thus reducing manpower requirements.

J3 UXV Training on the Job

- Background: Humans encountering a new and complex system spend time familiarising themselves with it, learning its capabilities and limitations so they can get the best out of that system.
- The challenge is for a UXV to recognise and capture the behaviour / response of a human operator in a variety of challenging situations such that it (and subsequently other UXVs) can mimic that behaviour in broadly similar situations.
- Effectively the UXV is trained with/by the operator rather than training the operator to use the UXV.
- Benefits of the training would be that the UXV would exhibit in operational use a series of learned behaviours that were not there when it left the factory gates.

J4 UXV Intuitive Behaviour

- Background: Autonomous systems will eventually always encounter situations for which the appropriate response has not been embedded within the system.
- The challenge is for an autonomous system
 - to recognise that it is in such a non-standard situation;
 - to respond with actions that either allows the situation to become similar to a “standard” situation or allows a “sensible” response (i.e. recondition the situation so that its behaviour is convergent at some level of abstraction);
 - to record the outcome (for J3).
- Note; “sensible” above covers actions that enable the UXV to continue functioning, and do not infringe boundary constraints (such as ROE)