Systems Design

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System Design

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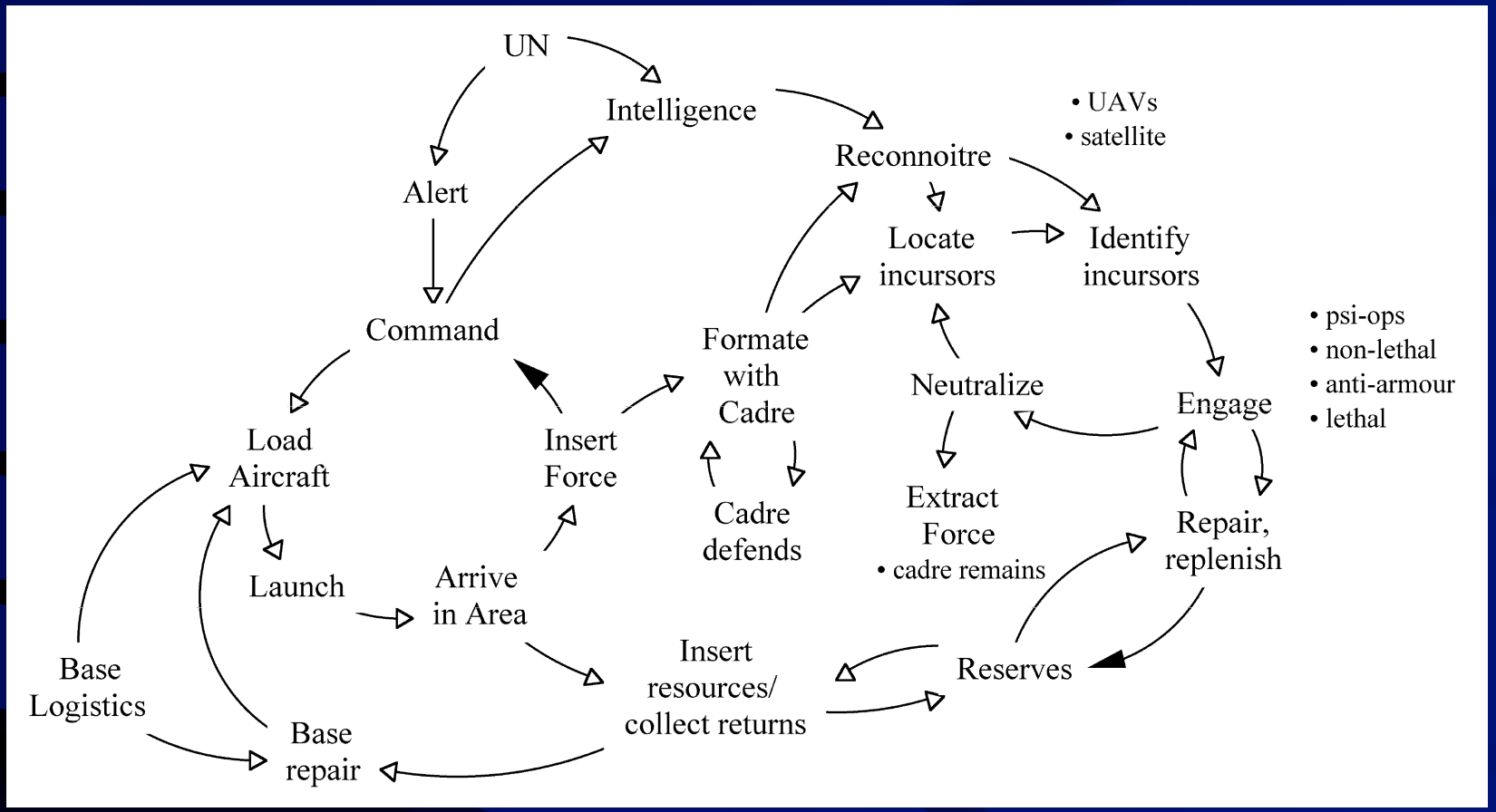
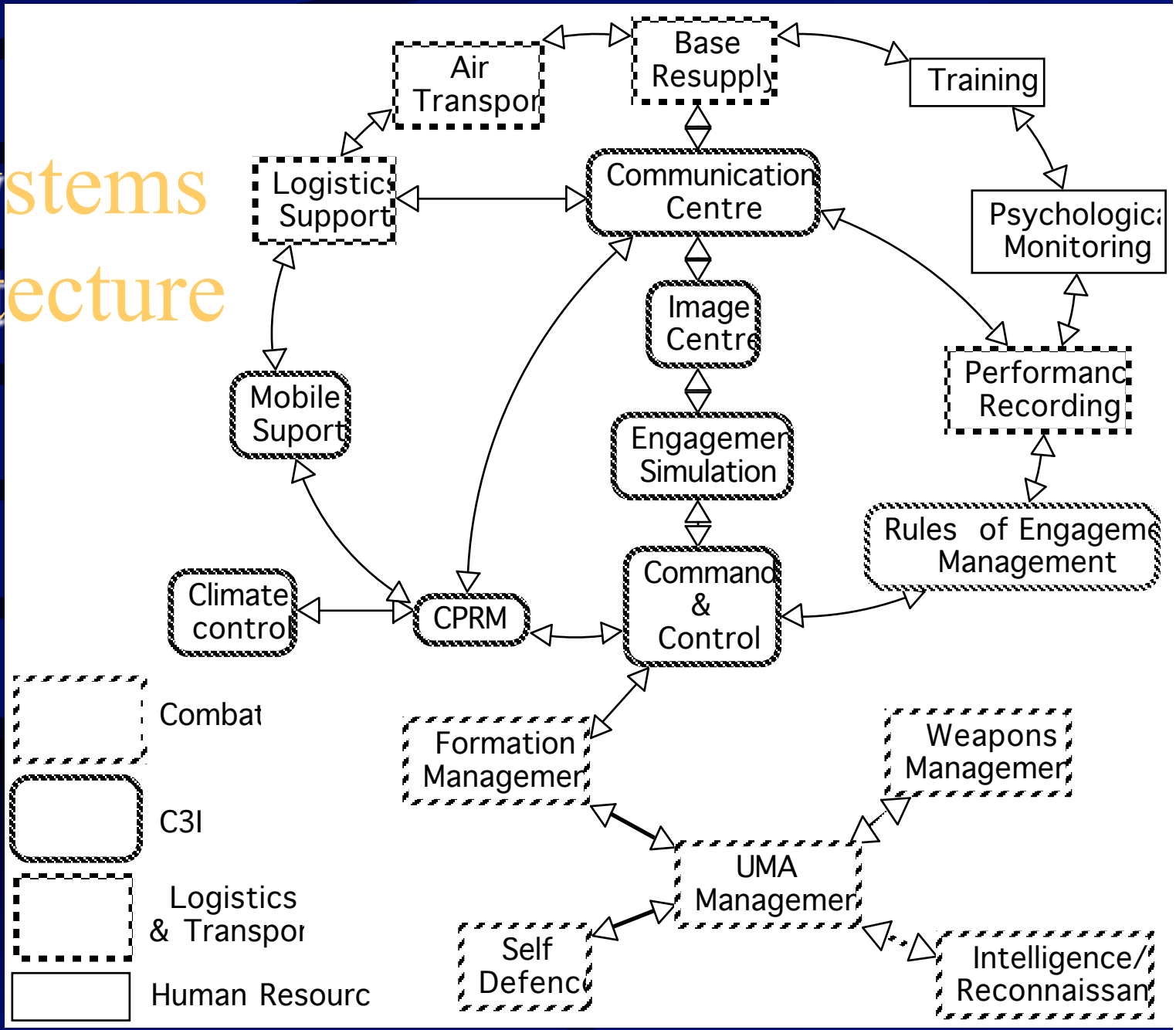
Mobile Land Force CONOPS

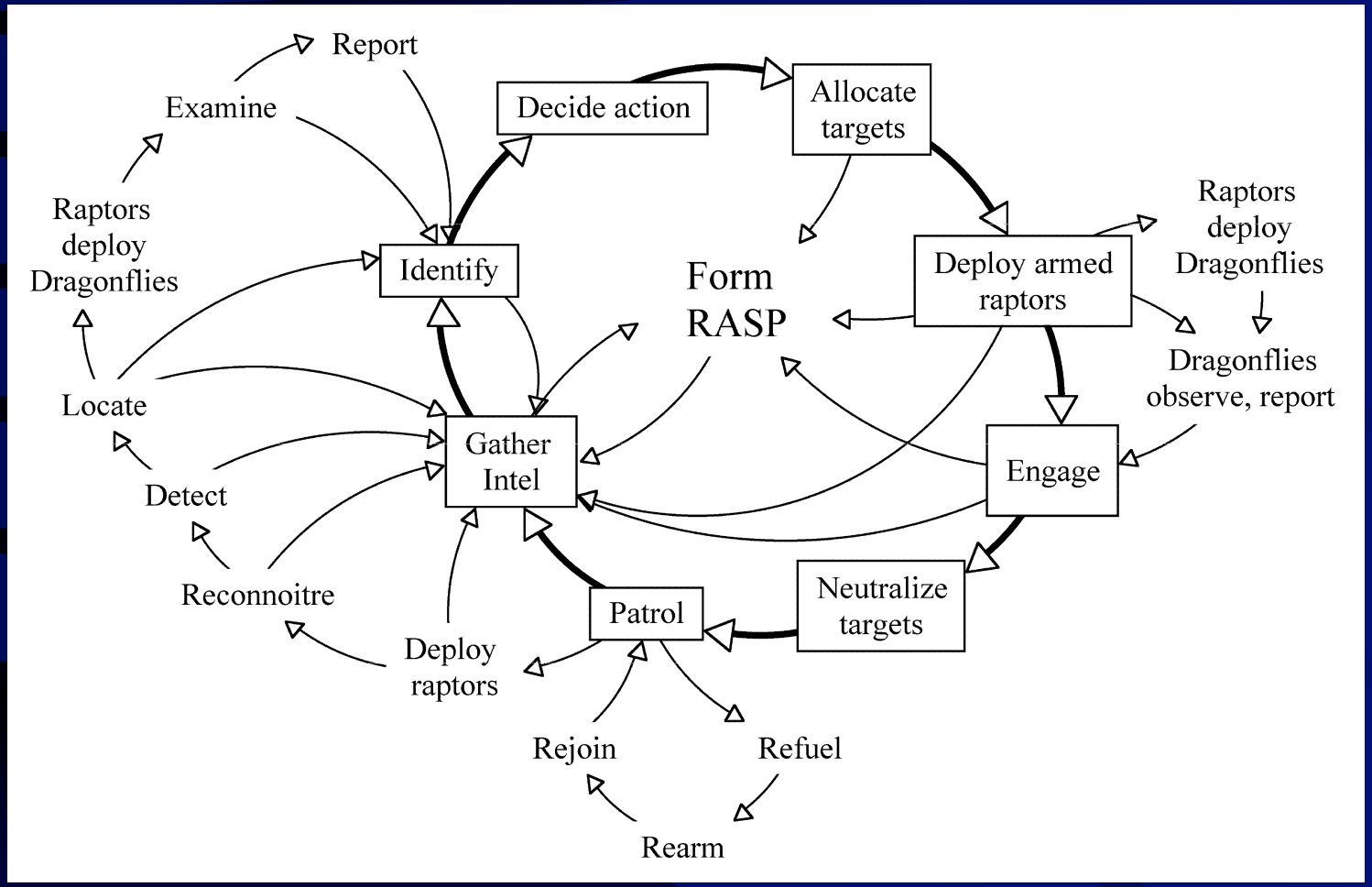


- Still at high level—we have yet to posit solution options…
- Note continuity of operations: once started, continues until all "incursors" neutralized
- This CLM may be simulated, using a non-linear dynamic modelling tool, to investigate:
  - Time delays • logistics • Effects of operations on reserves, maintenance, and *vice versa*
- Results of simulation (= operations analysis) may invoke changes to CONOPS
  - e.g. should transport aircraft be on airborne QRA to minimize delays?

3/3.Systems Architecture



Mission System CONOPS



Mojave Magic

UH! WHAT' S UP, DOC?

The Grand Challenge Feb 2003

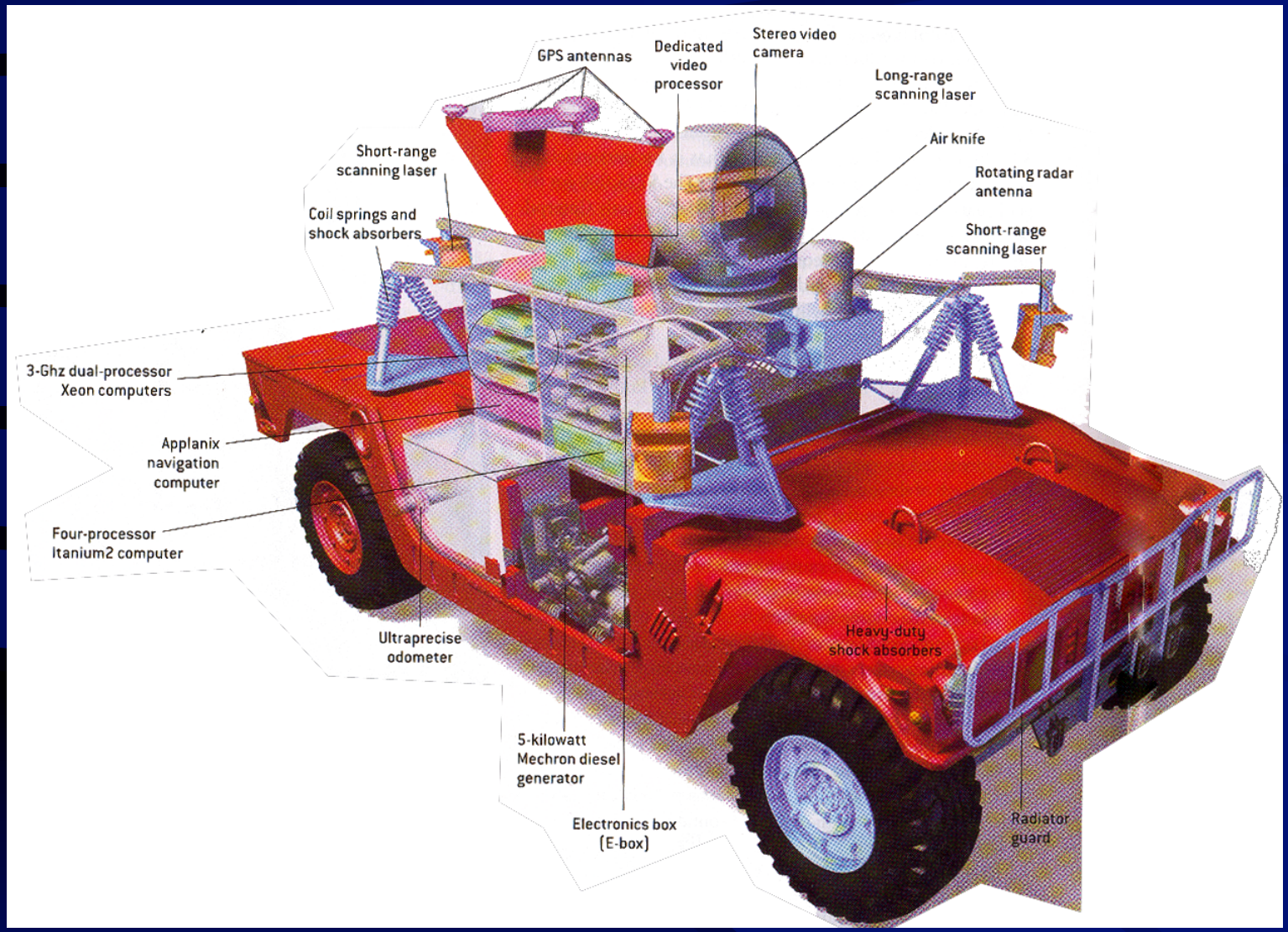
DARPA are offering $1,000,000 for the first robot vehicle crossing of the Mojave Desert.

200 miles of rough, unfamiliar terrain in ≤ 10 hours

Vehicles to be fully autonomous. No signals to be received except Stop.

No mutual interference.

Sandstorm—Carnegie Mellon's Entry



Scientific American,Volume 290, Number 3, March 2004

Breaking News,

New Scientist, 20 March, 2004

A robotic vehicle race across the Mojave Desert ended in disappointment last weekend with all 15 entrants failing to reach the finishing line. The favourite, Carnegie Mellon University's Humvee-based Sandstorm, veered off a mountainous dirt track just 11 kilometres along the 230-kilometre route and was only saved from plunging down a cliff when its undercarriage got stuck. But it travelled further than any other robot vehicle so far, and was the first to travel at 40 kmph.

The rest of the field - including a robot truck and the first autonomous motorcycle - ran into trouble even earlier. Seven refused to leave the starting line, with one flipping upside down and another zooming round in circles. The race was organized by the Pentagon to foster research into autonomous military vehicles.

- We may assume from this that the task of creating an autonomous robotic vehicle to operate in a desert is difficult
- It is also reasonable to assume that a robotic fighting fleet of vehicles is really beyond sensible capability
- However, that does not mean that we could not conceive, design and create a viable solution to Land Force 2010.
  - It is just not going to be autonomous/robotic
  - …which is a pretty scary idea anyway. Who wants potentially lunatic, uncontrolled robots wandering our deserts?
- DARPA hosting annual repeat until 2007—they must be serious…

What is "Systems Design"?

- Not obvious, once you ask the question…
- For a house/home, is it just the layout, the number, purpose and size of rooms? Or…
- …does it include the ancillaries
  - Electrical points, gas points, etc; air conditioning; waste disposal
- …does it include the immediate environment?
  - Garden, swimming pool, tennis courts, garage(s), encroaching neighbours, schools, shops, bus-stops, etc?
- Thinking about it, design could go on for ever—there have to be sensible levels of limit to detail.

Systems Design

- Yet again, because we are talking about systems, and about systems design as part of systems engineering
  - The design has to be holistic, organismic and synthetic
  - So, we have to design the *whole* system
    - Whatever that is
  - The design has to see the parts acting as a unified whole
  - The whole has to be made up from interacting subsystems
- In fact, looking at Land Force 2010, it is not unlike the challenges facing early Apollo.

From Experience…

- Looking back at Apollo…
- Several levels of system design
- Top level included
  - all of the major modules,
  - how they fitted together,
  - how they acted as one,
  - how they could separate, act independently, dock, etc
- Particularly, how they served the CONOPS
- In fact, more like their emergent properties, capabilities and behaviours
- Not very much about the internals of any of them
  - All of that is second level design—one for each major module, each with its own CONOPS - part of overall CONOPS.

Land Force 2010 Design

- …similarly, system design for LF2010 consists of:
  - Air transport vehicles, those loaded with the "transportable land elements" (TLEs)
  - TLEs forming the ground element of LF2010
  - UMA/RPVs forming the interdiction, air attack, air defence and close air support elements
    - As TLEs emerge from the transport aircraft, so ULAs emerge from the TLEs
- It may also be that some options require the transport aircraft, with appropriate systems and crews, to assume additional roles as forward air controllers, remote pilots for UAVs, and a communications relay
- The air transport element looks set to be viewed as an integral part of the system—as any feasible CONOPS would dictate anyway

Identifying an Option

- So far we have looked at function and behaviour—not form.
- We must consider form before we can proceed further
- The limiting form factor is the capacity of the transport aircraft
  - What weight it can carry
  - What size vehicle it can upload and insert
  - So, how many vehicles can it carry at once
  - …and what kind of aircraft is it anyway?

Identifying an Option

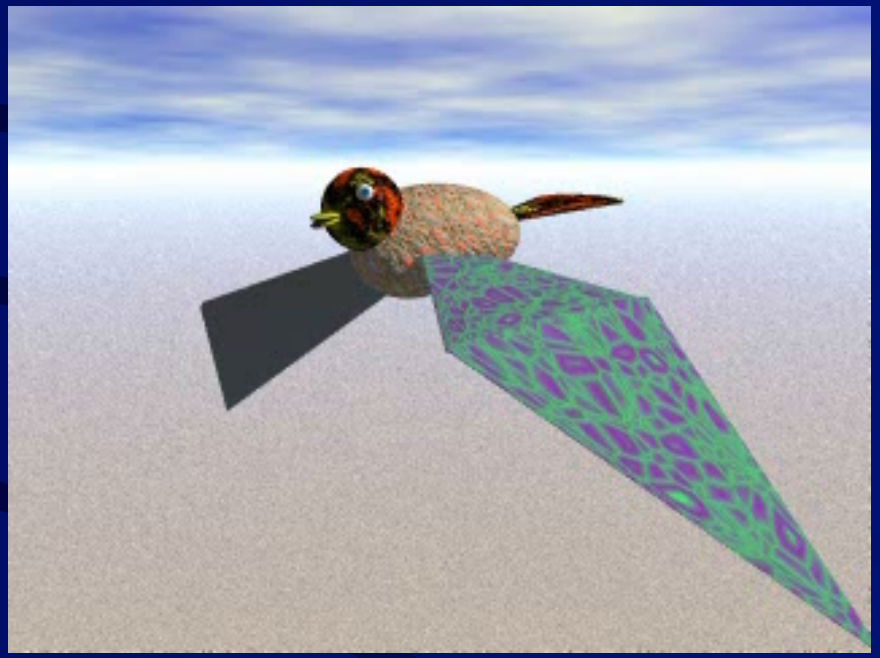
- As with Apollo, the delivery vehicle provides the overall limitation in terms of weight, size and shape
- The delivery vehicle also has to be appropriate to the operating environment
- We will assume a bespoke, V/STOL transport, 2,500nm hop when fully loaded, carrying capacity at max range = 35 tonnes
- This means that there will have to be more than one Land Force 2010 base around the world to provide "instant global cover."

Identifying an Option

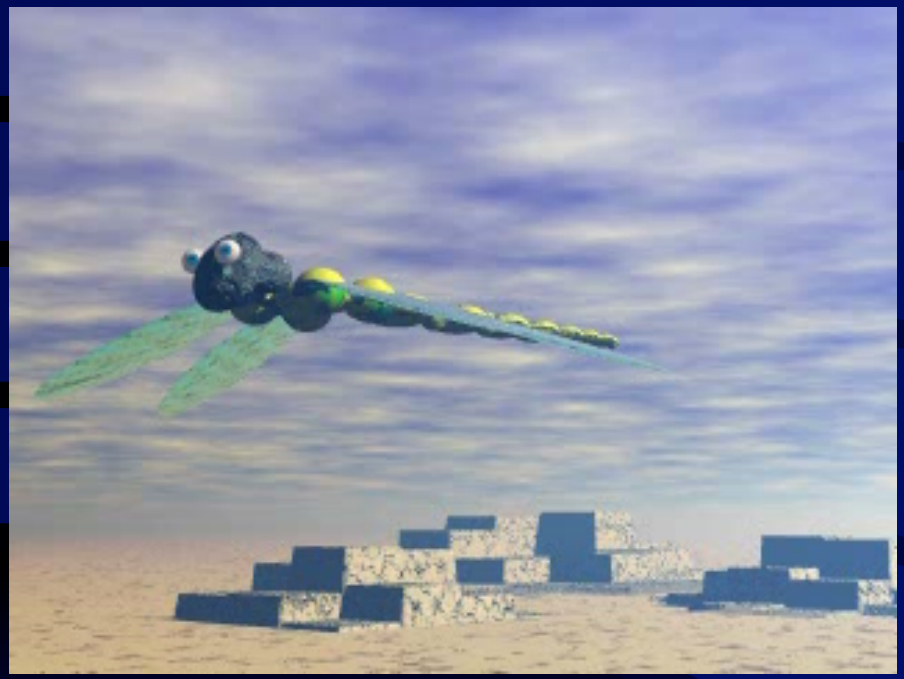
- 10-tonne vehicle–much lighter than a tank
- Concept employs vehicle agility and camouflage, rather than heavy armour for survivability
- Vehicles not intended to fight.
- Instead, they carry a wide range of UMA/RPVs that can deliver weapons
  - Operators not intended to come into contact with enemy
  - Hence, Blue casualties should be minimal…
    - In principle.

Surveillance

- Prototype raptor
- Uses nano-technology
- Uses biological parts
- Wings are solar panels
- Legs are radio antennae
- Eyes are video cameras
- Tail is “flat” radio lens
- Raptor able to soar and fly on its own
  - Can also be guided
  - Can carry “dragonflies”



Surveillance



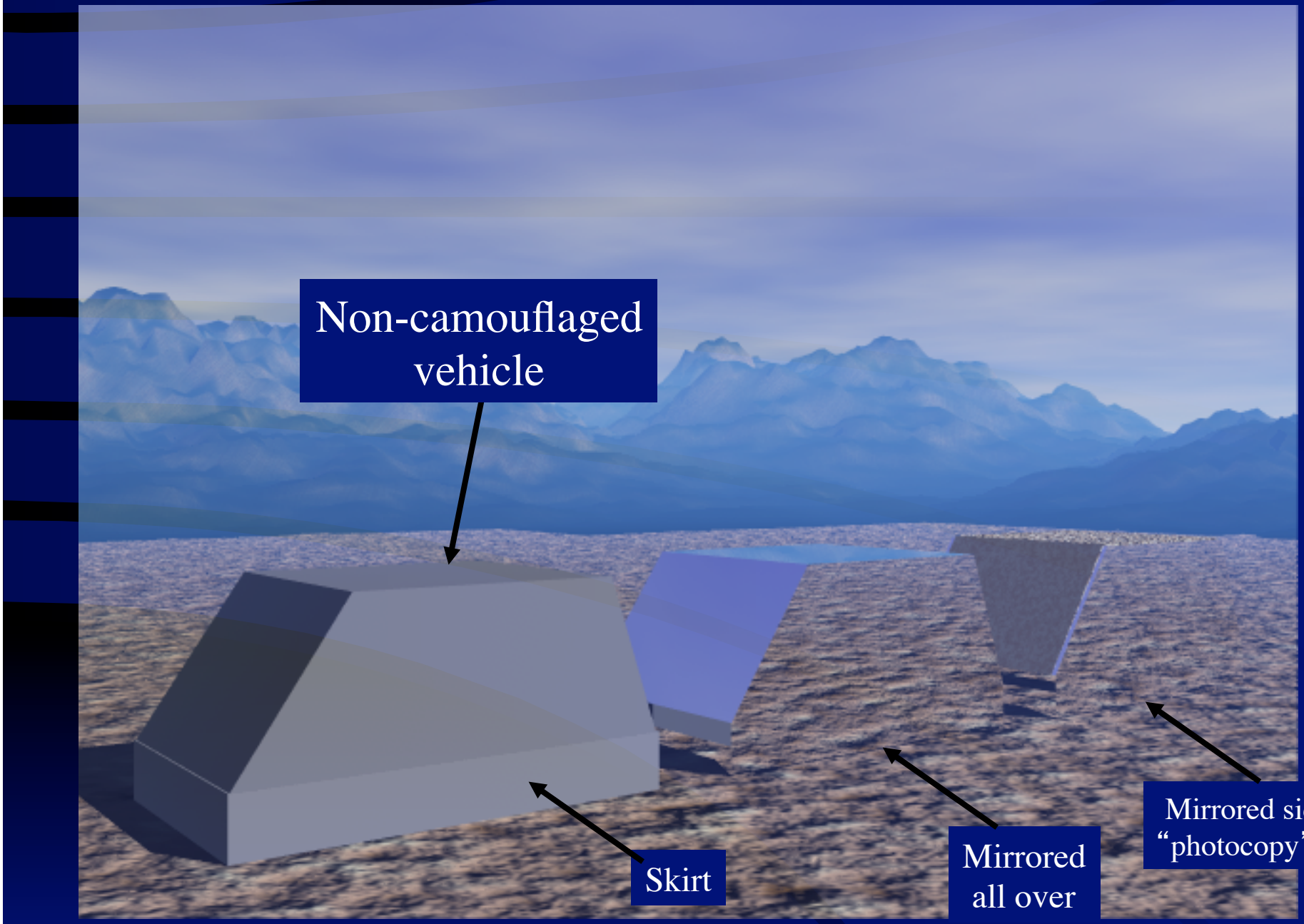
- Raptors deploy “dragonflies” for closer look
- Dragonflies use nano-technology, plus biological muscle inserts
- Graphic shows dragonfly reporting through raptor to C2 after exploring mud village.

Designing an Option

- Our solution option carries 3-TLEs at 10 tonnes each, in tandem in the cargo hold
- The remaining 5-tonnes are:
  - command and control + CPRM
  - remote vehicle control stations
    - TLEs
    - UAV/RPVs
  - intelligence suite
  - Communications, including satcom
  - logistic supplies
  - repair bays
- A full force might comprise 20+ such aircraft, with 60+ TLEs deployed at once, each with multiple UMA/RPVs active simultaneously, all on the go…

Designing an Option

- Each of the TLEs is externally similar
- Each has a skirt which can be used to hover
  - Get out of bogs, ponds, quicksand, cross water, ice, etc.
- Under the skirt are retractable drive wheels/half-tracks for normal road/off road use
- There are no windows, doors, or visible apertures
- The sides are covered with a material that can be induced to reflect like a mirror
- The top displays a live “photocopy” of the terrain being passed over
- In this way, the vehicle can be virtually invisible while stationary and on the move


Non-camouflaged vehicle
Skirt
Mirrored all over
Mirrored sides, "photocopy" top

Designing an Option

- Each TLE can be driven using full internal controls
- However, each can also be remotely controlled from another, or from the transport aircraft
- Vehicle supplied with stereo TV, and high definition radar
- Ongoing development may make the vehicles steer and drive autonomously in the future

Chameleon-on-the-Move

- Chameleon works reasonably in the desert
- Mainly shadow that is visible
- Fully developed system will have dust cloud obscuring shadow…

Designing an Option

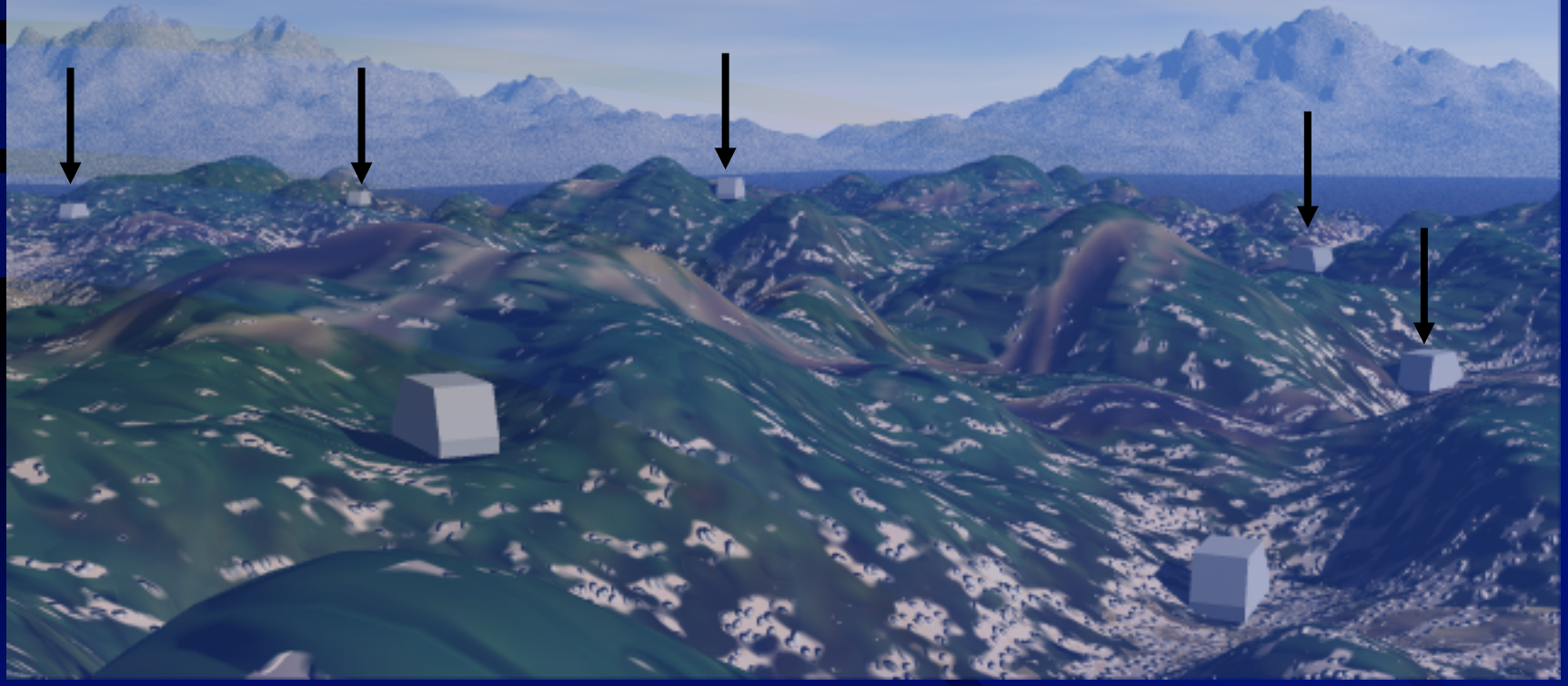
- Each vehicle carries UMA/RPVs and weapons
- Some UMA/RPVs used for reconnaissance, with live, encrypted TV link back to TLEs and transport aircraft
- UMA/RPVs launched on the go. Concealed roof panel opens, the UMA rises on a platform, resealing the TLE, and the UMA lifts off. The process takes less than 5 seconds.
- Recovery is the (automated) reverse procedure.

Designing an Option

- Other UMA/RPVs specialized:psi-ops, negotiation, confusion
  - Recce UMAs appear as raptors, gliding, soaring, aloft for hours, scouring ground for clues
- Other UMA/RPVs carry weapons:
  - Non-lethal personnel anti-riot weapons
    - Sleep-gases, stun devices
  - Area anti-technology weapons
    - SREMP
  - Area blast weapons
    - Fuel-air and thermobaric—work into buildings, caves, etc.,
  - Point impact and blast weapons
    - Energy weapons, rockets, canon, etc.
      - Energy weapon housed in TLE - beam reflected off UMA/RPV mirror. TLE operator sees target reflected through telescope, remotely adjusts mirror on UMA, fires, assesses damage—full SATKA cycle.
      - Development of SDI Fighting Mirror

TLE Swarm

- Incursors amassing on the plain between the near hills and the far mountains
- Swarm is approaching using ground cover concealment



Formation Control

- Movie shows small group of 9 LTEs
- They approach and “swarm” around a rocky outcrop
- Then they re-formate to approach a gully
- One file of three starts the climb up into the gully
- Two other files of three stand guard

TLE Swarm

- This simple 3-D simulation is the start of a large number of dynamic 3-D simulations
  - try out so-called “Swarm Operations”
    - different terrains against a variety of…
    - different targets
- We cannot know the targets in advance, but we can anticipate the different kinds of terrain that come under the headings “desert” and “tundra”
- In this way we can test if, and how well, this design meets the demands of the CONOPS

Network-Centric Swarm Ops.

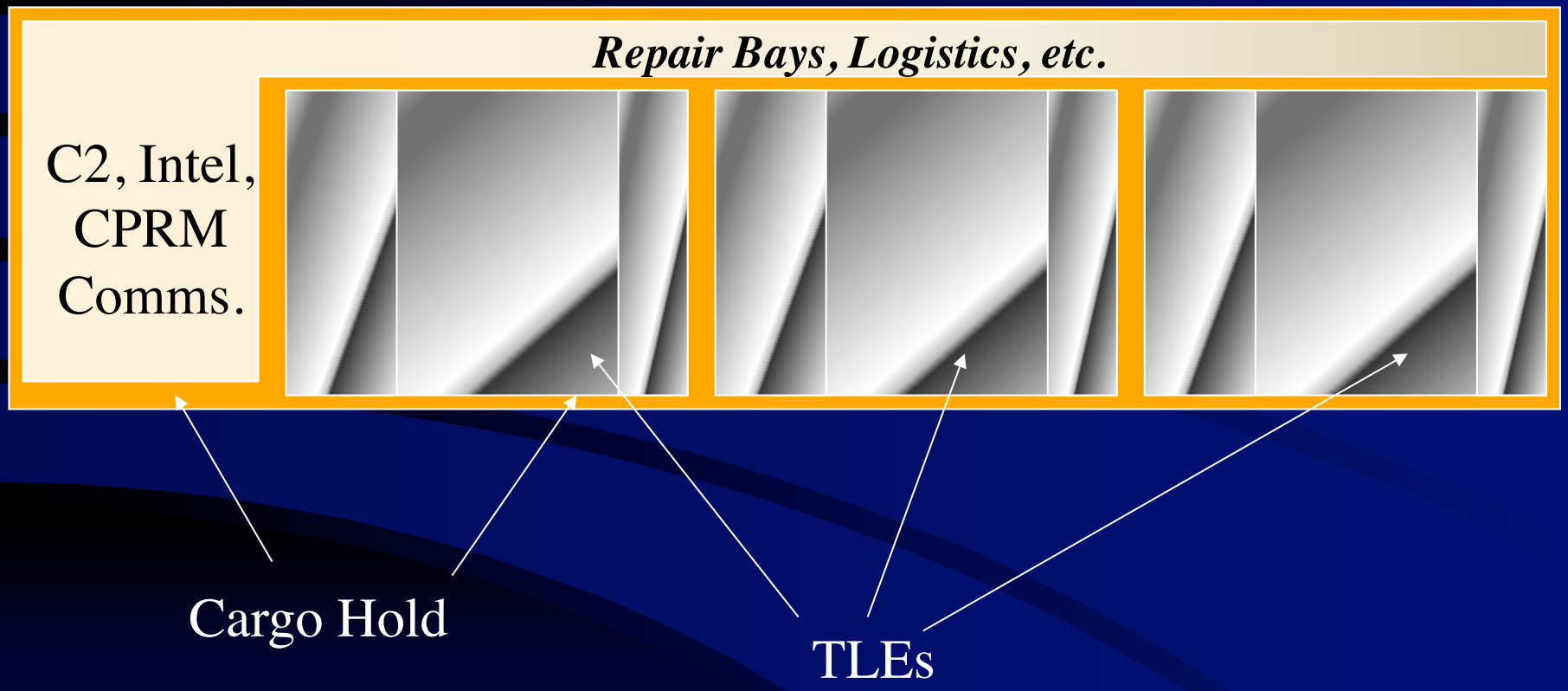
- Concept depends upon developmental technologies
  - several identified already
- One fundamental technology is the communications/navigation/identification (CNI) system that ties all the vehicles together
- This will be based on proven DTDMA design, but operating in an absorption band of the radio spectrum

DTDMA

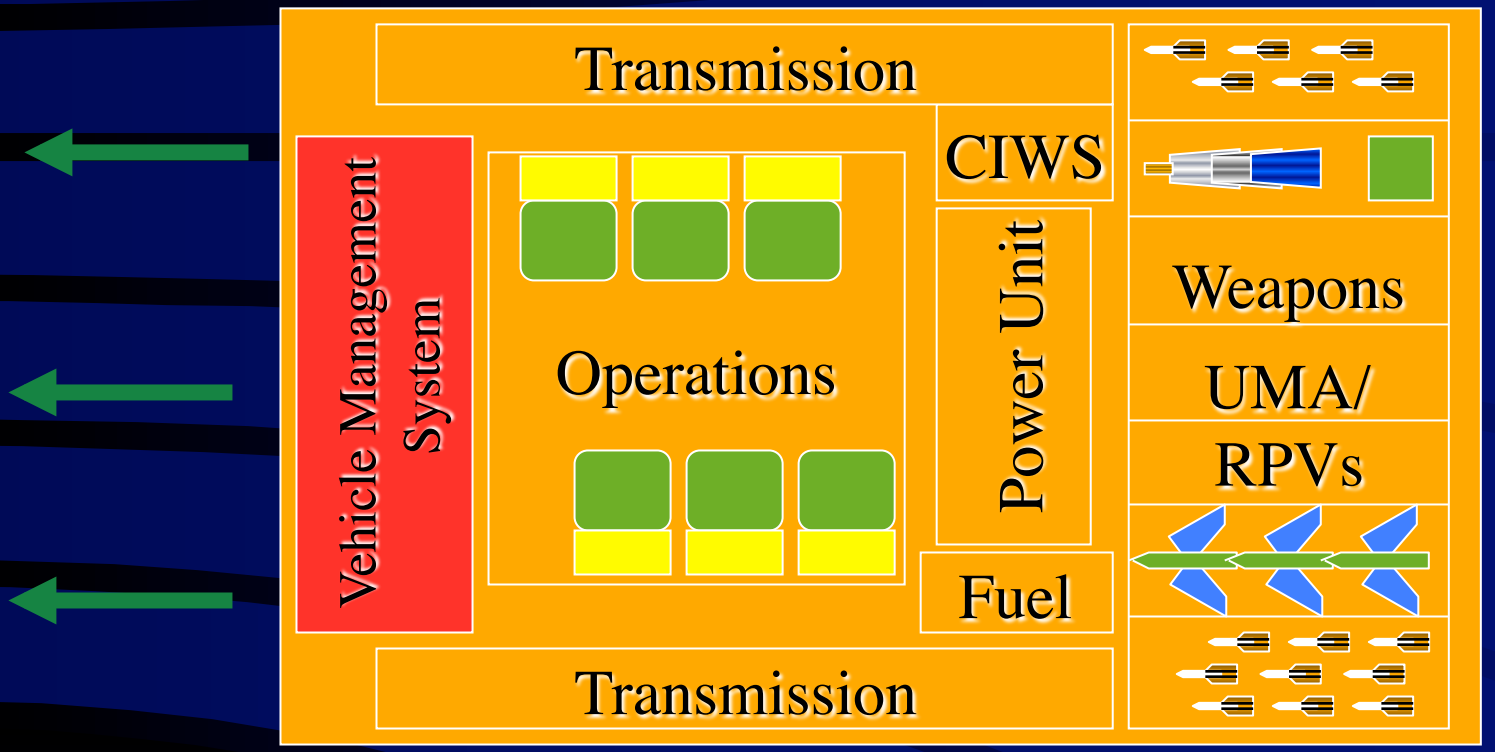
- An advanced, high capacity, non-nodal communications method
- Pseudo-random frequency hopping, transmission intervals, and chip phase coding combine to create a noise-like spectral output
- Highly resistant to detection, interception, jamming, direction finding. Use of absorption spectrum reinforces security
- Proven technology, although not at this frequency

Schematics (Air Transport)

V/STOL Transport Fuselage



Schematics (LTE)



- UMA/RPVs are self-arming, automatic takeoff
  - Appropriate stores coupled to air vehicles on rack-mounted chain belt system
  - Selected, armed, controlled by operations, within or without the LTE

So far…

- We have described our option
- We have identified many of its properties, capabilities and behaviours—in general terms
- And we could similarly describe other options – and validate them against their CONOPS
- In the process, we have identified a variety of new, novel and/or updated requirements: e.g., chameleon surfaces, raptor surveillance, etc.
- We have yet to be specific about vital parameters:
  - Power outputs, capacities, ranges, effectiveness…