Conceive Potential Solutions

Derek Hitchins
Starting with a Blank Space

• Maintain the highest level of abstraction;
• Make as few assumptions as possible;
• Challenge any and all presumptions;
• Identify obstacles to solution;
• Identify alternative ways to overcome obstacles;
• Creating alternative solution “maps”
• Model alternative solution concepts dynamically;
• Explore:
  • counterintuitive behaviour,
  • reactions from other systems,
  • resource demands, and likely costs;
• Select the “best” conceptual solution, where best may mean any or all of:
  • simplest, cheapest, best quality, lowest risk, most appealing, most exciting, most needed, and so on.
Concept Development

The TRIAD Building System
Prime Directive

System's Ultimate Purpose
Analysis of Prime Directive

Derived from Semantic Analysis

Objectives

Strategies to achieve Objectives
Strategies to overcome Threats

Activities/Functions to Achieve Strategies

Threats to Achieving Objectives

Organization/Management to Apply Resources

Strategies to Organize/Manage Resources
Strategies to overcome Threats

Threats to Organization/Management

Strategies to Establish/Maintain Resources

Resources to Establish/Maintain Activities/Functions

Threats to Establishing/Maintaining Resources

• Activities give Process Models
• Functions give Architectures

Activities/Functions to Achieve Strategies

• Activities give Process Models
• Functions give Architectures

Recurse to required detail
Using the TRIAD Building System — the Prime Directive

- Prime Directive = ultimate statement of purpose

- For Mobile Land Force, might be:
  1. To neutralize enemies in open desert and tundra regions around the world
  2. To deter potential enemies from operating in desert and tundra regions

- 1 subsumes 2, therefore 1 preferred

- PD is intentionally bare, with minimal assumptions
Semantic Analysis

• To neutralize …

• enemies in…

• open desert and…

• tundra regions…

• …around the world

• To render ineffective…

• those opposed to the US as identified by UN directive ABC existing and/or operating in…

• open, desolate, largely uninhabited tracts…

• and Arctic plains with permanently frozen subsoil, lichens, mosses, and dwarfed vegetation…

• wherever sanctioned by the UN

N.B. Definitions of desert and tundra areas quite inadequate.
Objectives from Semantic Analysis

**Semantic Analysis**

- To render ineffective...
- those opposed to the US as identified by UN directive ABC existing and/or operating in...
- open, desolate, largely uninhabited tracts...
- and Arctic plains with permanently frozen subsoil, lichens, mosses, and dwarfed vegetation...
- wherever sanctioned by the UN

**Implicit Objectives**

- To deploy swiftly
- To operate over wide areas radially different environments, temperatures, going, etc.
- To move rapidly to scenes of incursion/activity
- To identify legitimate enemies specifically
- To engage and deter, or overcome
- To operate within a UN mandate at all times
Strategies

Objectives

• To deploy swiftly
• To operate over wide areas radically different environments, temperatures, going, etc.
• To move rapidly to scenes of incursion/activity
• To identify legitimate enemies specifically
• To engage and deter, or overcome
• To operate within a UN mandate at all times

Strategies to Achieve Objectives

• Air transportable
• Air deliverable
• High powered, high speed, all terrain vehicles
• UMAs for remote identification and engagement where appropriate
• Vehicles to operate and fight on the move as an integrated unit, for speed, area coverage, avoidance of detection
• Fleet formation management to reduce enemy threat - open and tight, etc.
• Some vehicles to be self steering, but under control of personnel in nearby vehicle/command post.
Strategies to Overcome Threats to Achieving Objectives

Objectives

- To deploy swiftly
- To operate over wide areas radically different environments, temperatures, going, etc.
- To move rapidly to scenes of incursion/activity
- To identify legitimate enemies specifically
- To engage and deter, or overcome
- To operate within a UN mandate at all times

Strategies to Overcome Threats to Achieving Objectives

- Pre-deployed cadre forces in area
- Some WS/vehicles specialized for hot, wet, cold, ice, etc. conditions
- Use of non-lethal force to neutralize
- Use of armoured UMAs to accelerate ahead of ground force
  - Equipped: psy-ops, loudspeakers, leaflets, stun weapons, non-lethal anti-riot weapons
  - Equipped: fuel-air and thermobaric weapons (to warn as well as neutralize) + short-range electromagnetic pulse (SREMP)
  - Equipped: cannon, anti-tank missile, etc., anti-sniper lasers, enhanced remote ethnic/nationality laser identification
## From Strategies to Functions

<table>
<thead>
<tr>
<th><strong>Strategy</strong></th>
<th><strong>Implied Function</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>Air transportable</td>
<td>Dedicated air transport</td>
</tr>
<tr>
<td>Air deliverable</td>
<td>Palletised low-altitude insertion</td>
</tr>
<tr>
<td>High powered, high speed, all terrain vehicles</td>
<td>Highly-specialized vehicles</td>
</tr>
<tr>
<td>UMAs for remote identification and engagement where appropriate</td>
<td>UMA launch, control, operate and recover—on the move!</td>
</tr>
<tr>
<td>Vehicles to operate and fight on the move as an integrated unit, for speed, area coverage, avoidance of detection</td>
<td>UMA turn-round, repair, refuel, rearm, re-equip—on the move!</td>
</tr>
<tr>
<td>Fleet formation management to reduce enemy threat - open and tight, etc.</td>
<td>Formation control: reacts to threat, disperses, closes, re-arranges vehicle formations in face of threat from terrain and enemy</td>
</tr>
<tr>
<td>Some vehicles to be partly robotic, but under control of personnel in nearby vehicle/command post.</td>
<td>Mobile repair units, operating on the move</td>
</tr>
<tr>
<td></td>
<td>Short-range communications for security, “silent” running</td>
</tr>
</tbody>
</table>
From Strategies to Functions

**Strategy**

- Pre-deployed cadre forces in area
- Some WS/vehicles specialized for hot, wet, cold, ice, etc. conditions
- Use of non-lethal force to neutralize
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  - Equipped: canon, anti-tank missile, etc., anti-sniper lasers, enhanced remote ethnic/nationality laser identification

**Implied Function**

- Cadre forces maintenance, communications and intelligence
- Special vehicle support
- Lethal weapons training/practice
- Non-lethal weapons training
- Fuel-air and thermobaric weapons training/practice
- Human target identification
- Sniper location
- Real-time control of Rules of Engagement
Putting Flesh on the Bones
The Seven-Step Continuum

A codified approach, ensuring thoroughness, coverage and speed.
SSC - Step 1

1/1 Nominate System of Interest: Mobile Land Force 2010

1/2 Explore Boundaries and Finite States: Complementary set of interacting, all
terrain, fighting vehicles operating multiple UAVs after the manner of a land-
based aircraft carrier task force. States: training, standby, operational, recovery,
turnaround & repair

1/3 Identify SOI Sibling Systems: air transport, air insertion, air recovery, satellite
intelligence, satellite comm/nav, logistic support, repair facilities, vehicle
recovery

1/4 Identify & Explore Environment: desert & tundra, varied, wide temperature
variation, plains with rocky outcrops, frozen lakes, little vegetation, v.sparingly
populated if at all

1/5 Identify SOI Containing System and Objectives: US Global Peace Command. To
neutralize enemy incursions into UN designated global deserts and tundra

1/6 Identify and Explore Influences on SOI: Political desire to operate without loss
of US lives. UN desire to operate without loss of any lives. US belief in advanced
hi-tech weapon systems. US defense business interest in developing advanced,
non-lethal weapons

1/7 Identify and Prescribe Interactions and Resources: Air Transport and Insertion;
resupply; intelligence; RoE; fuel, weapons and consumables; UAVs; trained
operators; repair staff, logisticians, communications, satellite navigation, etc., etc.
SSC–Step 2

2/1 Establish SOI Prime Directive: to neutralize enemy incursions into UN designated desert and tundra swiftly and with minimal loss of life

2/2 Postulate Strategy to achieve PD: see TRIAD Building System

2/3 Postulate Threat to PD: see TRIAD Building System

2/4 Develop Measures of SOI Effectiveness:
a) time to scene b) time to neutralize c) degree of neutralization d) Blue casualties e) Red casualties f) operation costs & cost effectiveness g) cost exchange ratios h) casualty exchange ratios

2/5 Conceive SOI Functions and Activities: Time for CONOPS!

2/6 Establish SOI Needs Template:
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?
2/5 Conceive SOI Functions and Activities

Functions to Achieve Strategies

- Cadre forces maintenance, communications and intelligence
- Special vehicle support
- Lethal weapons training/practice
- Non-lethal weapons training
- Fuel-air and thermobaric weapons training/practice
- Human target identification
- Sniper location
- Real-time control of Rules of Engagement
- Dedicated air transport
- Palletised low-altitude insertion
- Highly-specialized vehicles
- UMA launch, control, operate and recover—on the move!
- UMA turn-round, repair, refuel, rearm, re-equip—on the move!
- Formation control: reacts to threat, disperses, closes, re-arranges vehicle formations in face of threat from terrain and enemy
- Mobile repair units, operating on the move
- Short-range communications for security, “silent” running

Operational functions from CONOPS

- Intelligence development
- Reconnaissance
- Command & control
- Force extraction
- Base resupply / repair
- Force self defense

- Lists at left and above derived from operational considerations
- Ignore hosts of internal functions essential to establish and maintain any mobile, yet unified, fighting force
- These can be derived using a Generic Reference Model (GRM)
2/6. Requirements Template-Generic

- Now able to develop a Requirements Template
- Generic Version shows what we have done, and what remains...

<table>
<thead>
<tr>
<th></th>
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</thead>
<tbody>
<tr>
<td>Strategy for Achieving Prime Directive</td>
<td></td>
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</tr>
<tr>
<td>Behaviour</td>
<td>Strategy</td>
<td>Management Set</td>
</tr>
<tr>
<td>Aggression</td>
<td>Strategy options</td>
<td>Mission management</td>
</tr>
<tr>
<td>Discretion</td>
<td>Unifying concepts</td>
<td>Viability management</td>
</tr>
<tr>
<td>Co-operation</td>
<td>Innovative approaches</td>
<td>Resource management</td>
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</table>

<table>
<thead>
<tr>
<th>Measures of S-O-I effectiveness</th>
<th>Negative contribution factors</th>
<th>Threat to achieving PD</th>
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<tbody>
<tr>
<td>Performance</td>
<td>Cost</td>
<td>External</td>
</tr>
<tr>
<td>Availability</td>
<td>Mass/weight/volume</td>
<td>Internal</td>
</tr>
<tr>
<td>Survivability</td>
<td>Complexity</td>
<td>Environmental</td>
</tr>
<tr>
<td></td>
<td>Failure modes/criticality</td>
<td>Political/economic/</td>
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<tr>
<td></td>
<td></td>
<td>social/technical</td>
</tr>
</tbody>
</table>

| | | |
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### GRM—Doing

**Internal Architecture Generation Table**

<table>
<thead>
<tr>
<th>Mission Management</th>
<th>Viability Management</th>
<th>Resource Management</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Management of...</em></td>
<td><em>Management of...</em></td>
<td><em>Management of...</em></td>
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<table>
<thead>
<tr>
<th>GRM</th>
<th>SOI</th>
<th>GRM</th>
<th>SOI</th>
<th>GRM</th>
<th>SOI</th>
</tr>
</thead>
<tbody>
<tr>
<td>–information</td>
<td>Com. centre Image Centre</td>
<td>–synergy</td>
<td>Formation management C2</td>
<td>…acquisition</td>
<td>CPRM Base Resupply Training</td>
</tr>
<tr>
<td>…objectives</td>
<td>CPRM</td>
<td>…survival</td>
<td>Formation management Self Defense System</td>
<td>…storage</td>
<td>Logistic support vehicles Ready use stores</td>
</tr>
<tr>
<td>…strategy &amp; plans</td>
<td>Command &amp; Control (C2)</td>
<td>…evolution</td>
<td>Performance Recording Systems</td>
<td>…distribution</td>
<td>Mobile Distribution Fleet</td>
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<tr>
<td>…execution</td>
<td>C2</td>
<td>…homeostasis</td>
<td>Climate control</td>
<td>…conversion</td>
<td></td>
</tr>
<tr>
<td>…cooperation</td>
<td>C2</td>
<td>…maintenance</td>
<td>Mobile maintenance teams</td>
<td>…disposal</td>
<td>CPRM</td>
</tr>
</tbody>
</table>

**CPRM:** Contingency Planning and Resource Management

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## GRM—Thinking

### Internal Architecture Generation Table

<table>
<thead>
<tr>
<th>Cognition Management Management of...</th>
<th>Selection Management Management of...</th>
<th>Stimulation Management Management of...</th>
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</thead>
<tbody>
<tr>
<td><strong>GRM</strong></td>
<td><strong>SOI</strong></td>
<td><strong>GRM</strong></td>
</tr>
<tr>
<td>…tacit knowledge</td>
<td>Desert &amp; tundra combat experts OJT</td>
<td>–nature</td>
</tr>
<tr>
<td>…world models</td>
<td>Maps, satellite imagery, cultural perception</td>
<td>…experience</td>
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<tr>
<td></td>
<td></td>
<td>…constraint</td>
</tr>
</tbody>
</table>

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## 3/2. Land Force 2010. Omissions Identified

<table>
<thead>
<tr>
<th>Department</th>
<th>Code</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Clim Contr</td>
<td>1</td>
<td>J</td>
</tr>
<tr>
<td>Wpns Man</td>
<td>2</td>
<td>S 1</td>
</tr>
<tr>
<td>Int/Recce</td>
<td>3</td>
<td>R 1</td>
</tr>
<tr>
<td>UMA Man</td>
<td>4</td>
<td>1 1 Q 1</td>
</tr>
<tr>
<td>Self Def</td>
<td>5</td>
<td>1 P 1</td>
</tr>
<tr>
<td>Formate Man</td>
<td>6</td>
<td>1 O 1</td>
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<tr>
<td>C and C</td>
<td>7</td>
<td>1 N 1</td>
</tr>
<tr>
<td>Engage Sim</td>
<td>8</td>
<td>M 1</td>
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<tr>
<td>Image Centre</td>
<td>9</td>
<td>1 L 1</td>
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<tr>
<td>Mobile Sup</td>
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<td>H 1 1</td>
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<tr>
<td>CPRM</td>
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<td>1 I 1</td>
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<td>Log Supp</td>
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<td>1 G 1 1</td>
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<tr>
<td>Comm Centre</td>
<td>13</td>
<td>1 1 K 1 1</td>
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<tr>
<td>Air Transp</td>
<td>14</td>
<td>1 F 1</td>
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<tr>
<td>Base Resup</td>
<td>15</td>
<td>1 E 1</td>
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<tr>
<td>Training</td>
<td>16</td>
<td>1 D 1</td>
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<tr>
<td>Perf Rec</td>
<td>17</td>
<td>1 C 1 1</td>
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<td>Psych Mon</td>
<td>18</td>
<td>1 B 1</td>
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<tr>
<td>ROE Man</td>
<td>19</td>
<td>A 1 1</td>
</tr>
</tbody>
</table>
3/4. Interacting Subsystems

C3I: Command, control, communications and intelligence
3/1. Systems Overview
### 3/5. SOI Solution Template (Generic)

<table>
<thead>
<tr>
<th>EFFECTIVENESS</th>
<th>OPTIONS</th>
</tr>
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<tbody>
<tr>
<td></td>
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<tr>
<td>PERFORMANCE - Container's Objectives</td>
<td></td>
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<tr>
<td>- Sibling Interaction</td>
<td></td>
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<tr>
<td>- Subsystem Harmony</td>
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<tr>
<td>AVAILABILITY - Reliability</td>
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<tr>
<td>- Maintainability</td>
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<tr>
<td>- Re-Configurability</td>
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<tr>
<td>SURVIVABILITY - Avoidance of Detection</td>
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<tr>
<td>- Self Defence</td>
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<tr>
<td>- Damage Tolerance</td>
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<td>INTEROPERABILITY</td>
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<td>USABILITY</td>
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<tr>
<td>SECURITY, ETC</td>
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<tr>
<td>COST</td>
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<td>ADVERSE PARENT MISSION FACTORS</td>
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<td>FAILURE PATTERNS</td>
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<td>CONSUMPTION</td>
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<td>DISSIPATION</td>
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<td>MASS / WEIGHT</td>
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<td>VOLUME / SHAPE, ETC</td>
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<td>NET CONTRIBUTION</td>
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Rigorous Soft Method

- So far, we have
  - identified problem symptoms,
  - grouped them into problem themes,
  - modelled an ideal world (N2 chart, etc.),
  - identified differences - SID.
- We have used parts of the GRM, only
- We have yet to generate criteria for a good solution…
Solution Concept Options

- Only GRM (Function) and GRM Behaviour) used so far: GRM (Form) outstanding—identifies power, structures…
- Now able to posit optional (physical) solution concepts
- Idea is emerging of a highly mobile and transportable land force
- May be air-inserted near scene of activity
- Makes extensive use of UMAs
- Concept not dissimilar to a naval task force formed around an aircraft carrier
- Carrier aircraft recce., defend fleet, mount attacks ahead of fleet.
- Carrier vulnerable, however - considerable effort expended to defend it
Solution Concept Options

• Land force 2010 could be:

• Formed around a “carrier” able to launch and retrieve UMAs while on the move. Other fighting vehicles/aircraft needed to defend carrier

• Or, could comprise several vehicles, some able to launch, others able to retrieve, with yet others able to control - functional split. Other fighting vehicles to defend UAV core force.

• Or, could comprise a number of semi-autonomous vehicles, each able to move, fight, launch, control and retrieve own UAVs.
Solution Concept Options (Cont.)

• Many more options to consider.
• What if the UMA’s cannot get airborne, cannot see, get shot down? Can the terrestrial vehicles find the enemy, engage and defend themselves?
• What about survivability?
  – Avoidance of detection?
    • stealth, camouflage, terrain following, passive radars, “noise” CNI radios
  – Self defence?
    • New CIWS: new guided-energy weapon–multiple simultaneous engagements, doubles as attack weapon, beams reflected off mirrors on Blue UMAs
  – Damage tolerance?
    • Light-weight active armour, multiple redundancy at vehicle and systems levels, self-healing systems, 0n-the-move damage repair teams…
Task

• Consider each of the optional solutions, and one other of your own

• Develop a distinct CONOPS for each, highlighting any differences.

• Are you able to identify the relative strengths and weaknesses of the options
  – How well? How sure are you?

• Are you able to choose which you prefer?
  – How firm is your choice?
  – Could you *prove* (e.g. to your boss) that your choice is the best?

• Could there be much better, quite different options? How would we know? How could we find out?
Codifying Conception
Route Map

- From problem space to system solution