SE & Defence Procurement

Optimizing the Total System

Professor Derek K Hitchins

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Systems engineering Principles

- Systems engineering is, essentially, a problem solving methodology, e.g.,
  - "The art and science of creating optimal system solutions to complex problems"
- The proper application of systems engineering observes three fundamental system tenets:
  - **Holistic**—encompass the whole issue or problem
  - **Organismic**—all parts interact to behave as a unified whole
  - **Synthetic**—bring parts together under a single, overarching CONOPS and architecture
    - No Cartesian reduction - it contradicts the first two tenets

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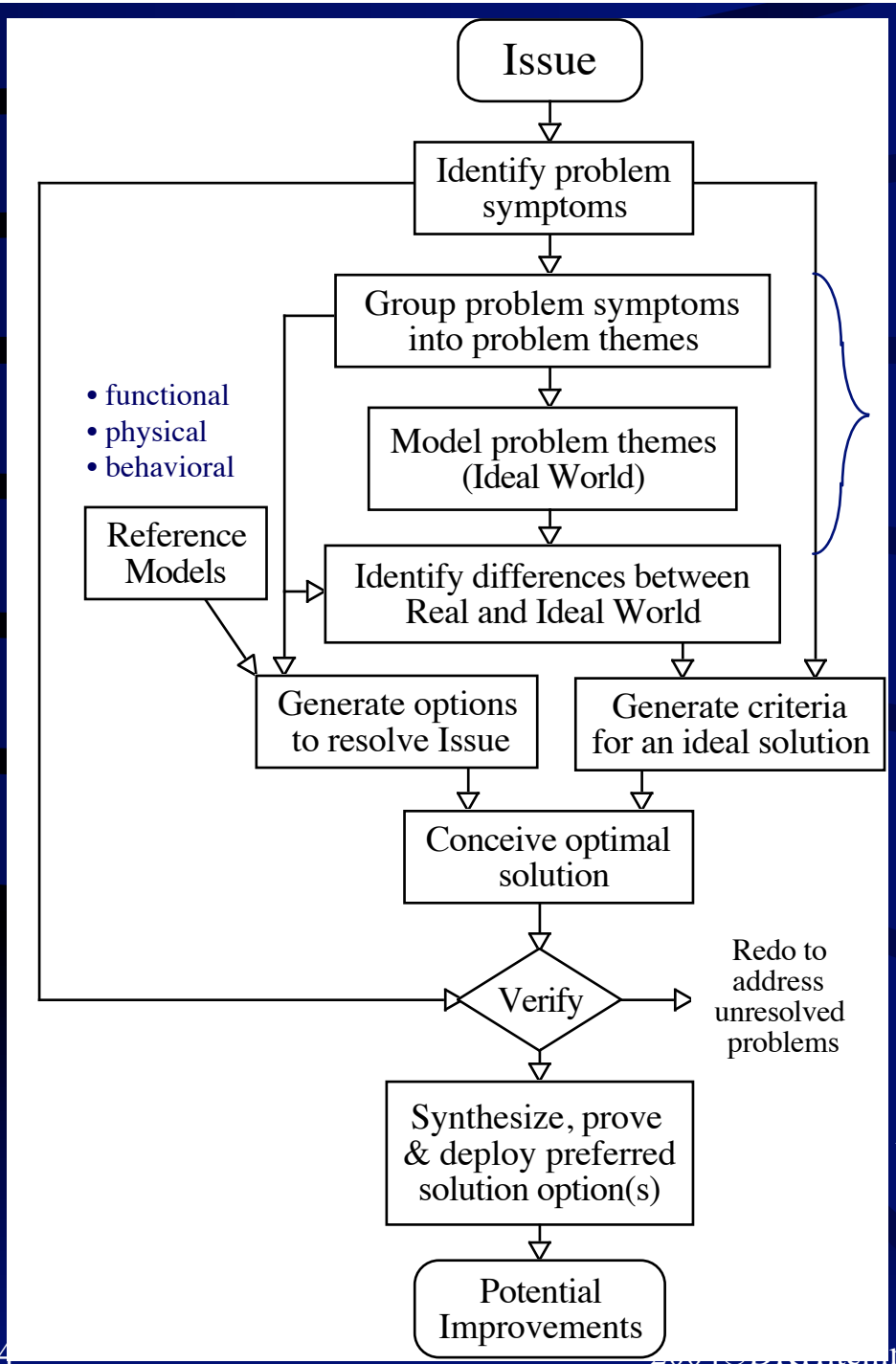
Systems Engineering Paradigm



Address **all** problem components to avoid (Forrester's) Counter-intuitive response

Use tools and methods to accommodate complexity

Ensure solution completeness— if any solution exists

Avoid reduction to maintain solution system coherence

Logical, consistent, but not necessarily culturally acceptable

SE & Defence Acquisition

- Smart Procurement /Acquisition appears to be neither holistic nor organismic
- System of Systems appears to be "bottom-up-integration"
  - Dangerously incorrect method of joining systems
  - cause of many disasters in the past
- *Prima facie*, Defence Acquisition not consistent with systems engineering in UK *or* US
  - UK and US both effectively failed to introduce Japanese-style lean commercial SE, COTS, etc…
  - …as required by Lord Robertson in UK, 1996/7
  - …and by US Administration c.1995(?)

…taking a fresh look…

…but, is it already too late…?

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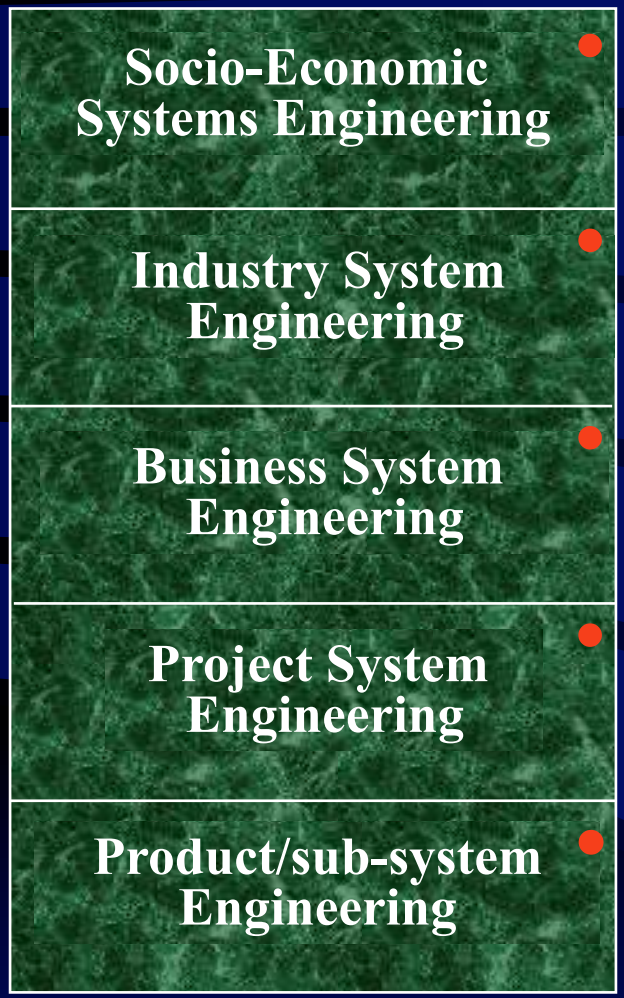
The 5-Layer Systems Engineering Model



International Commonwealth. Social, economic, political and defence interactions.

National Wealth Creation, the Nation's Engine. (Japan operates at this level)

Industrial Wealth Creation. Many Businesses make an industry

Corporate Wealth Creation. (The West operates at this level.)

Technology Artefacts. To some the only "real" systems engineering. Many Products (can) make a system

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SE at Levels 4 & 5

- Contemporary "SE" in US & UK aimed exclusively at Levels 1 & 2:
  - Purpose: to engineer technological artefacts/systems
  - Employs questionable heuristics
  - Underwritten neither by theory nor science
  - Wholly inappropriate for application at Levels 4 & 5
- Levels 4 & 5 SE:
  - Purpose: to conceive/design/ optimize/develop/create:
    - socio-technical systems, socio-political systems, organizational systems, national/global industries, pipeline systems, national/ international defence…
    - …and people systems—but not technological systems
- Surprise 1: Level 1 & 2 engineering heuristics don't work too well at Levels 3 & 4
- Surprise 2: there is a scientific Systems Methodology (SM) that works at any level
- Let's do some Systems Analysis

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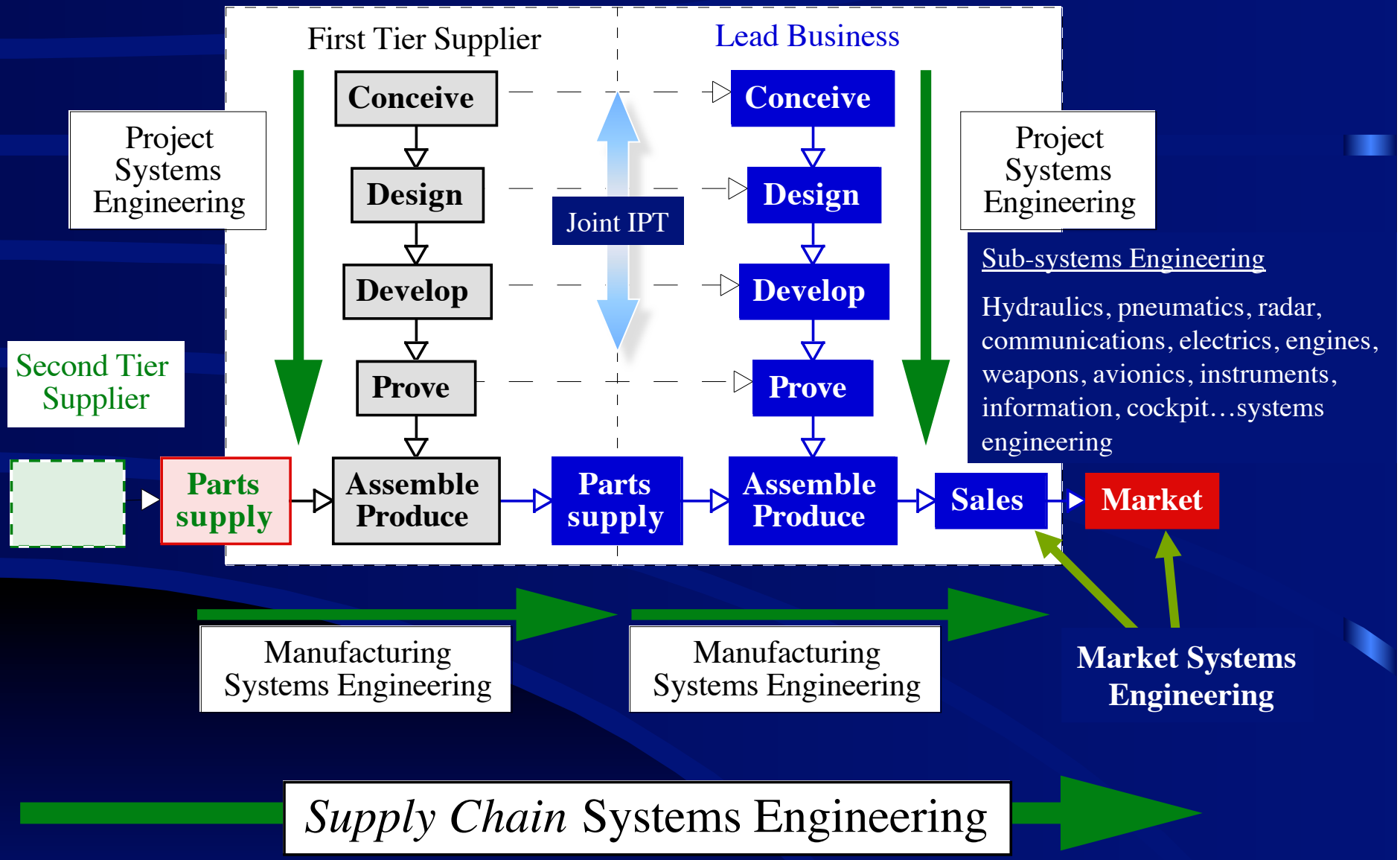
Inside Industry Systems Engineering



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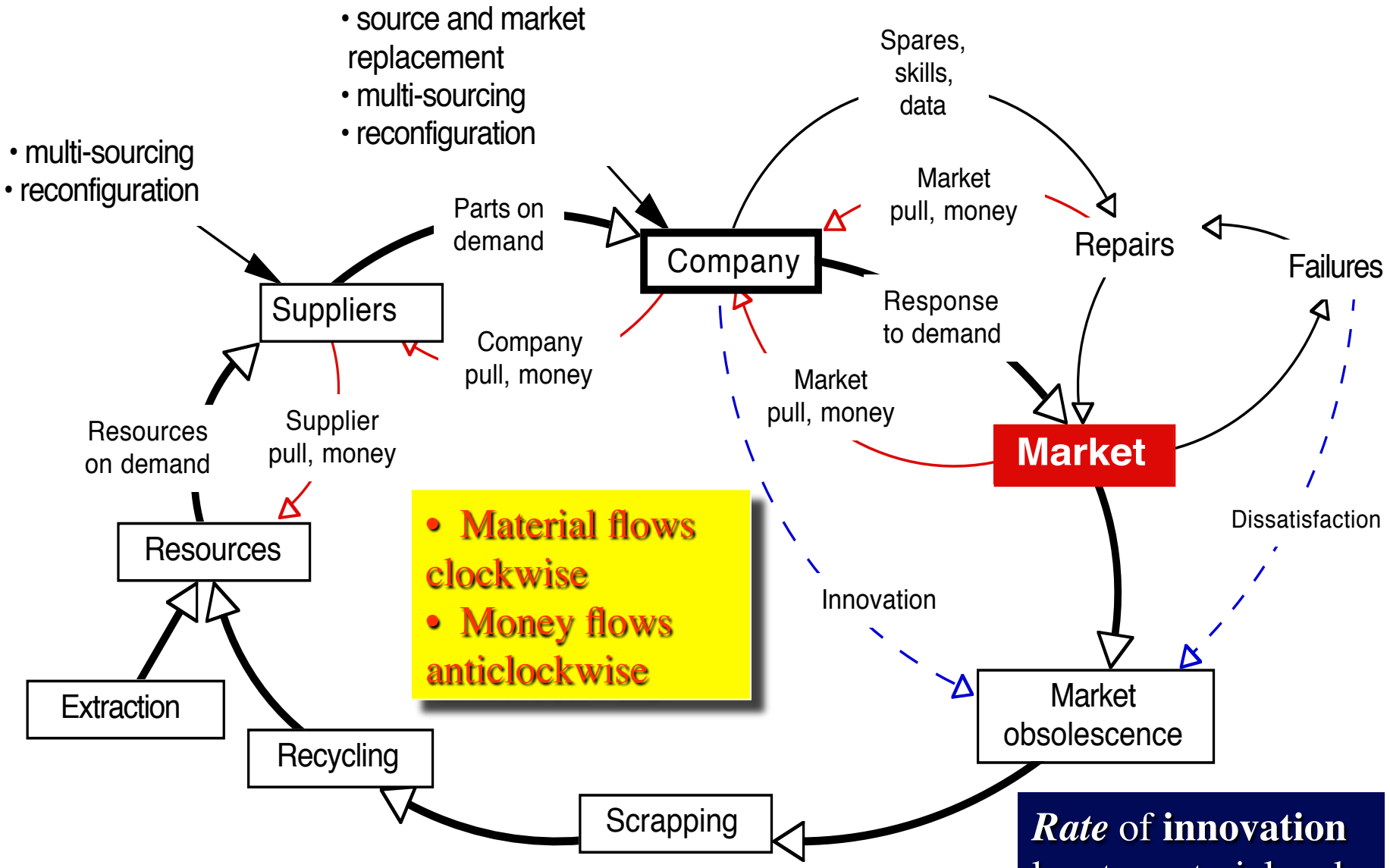
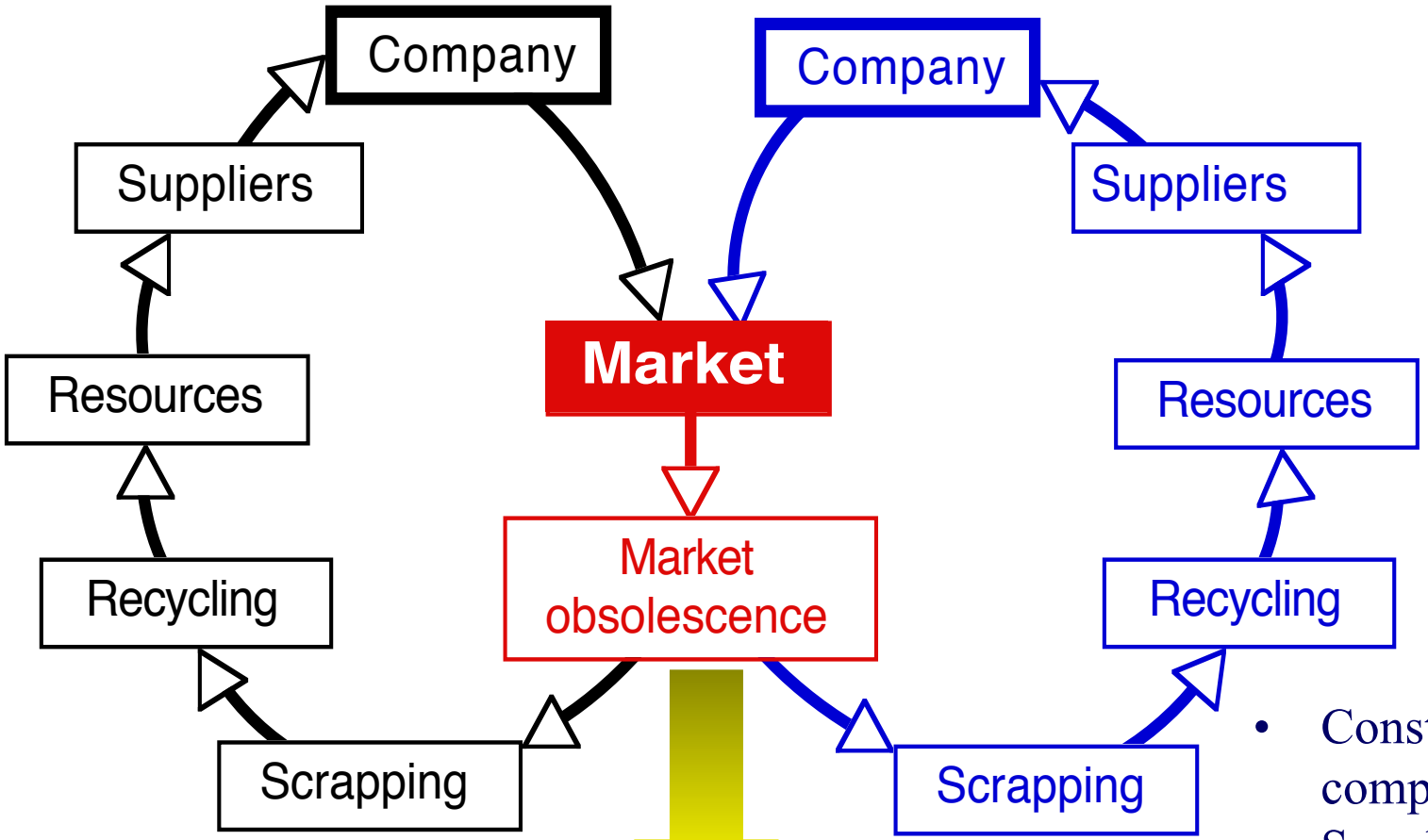
Japanese, Agile Lean Volume Supply System



Rate of **innovation** key to material and money flow rates

- Circle becomes progressively leaner, more efficient and more effective over time using Kaizen

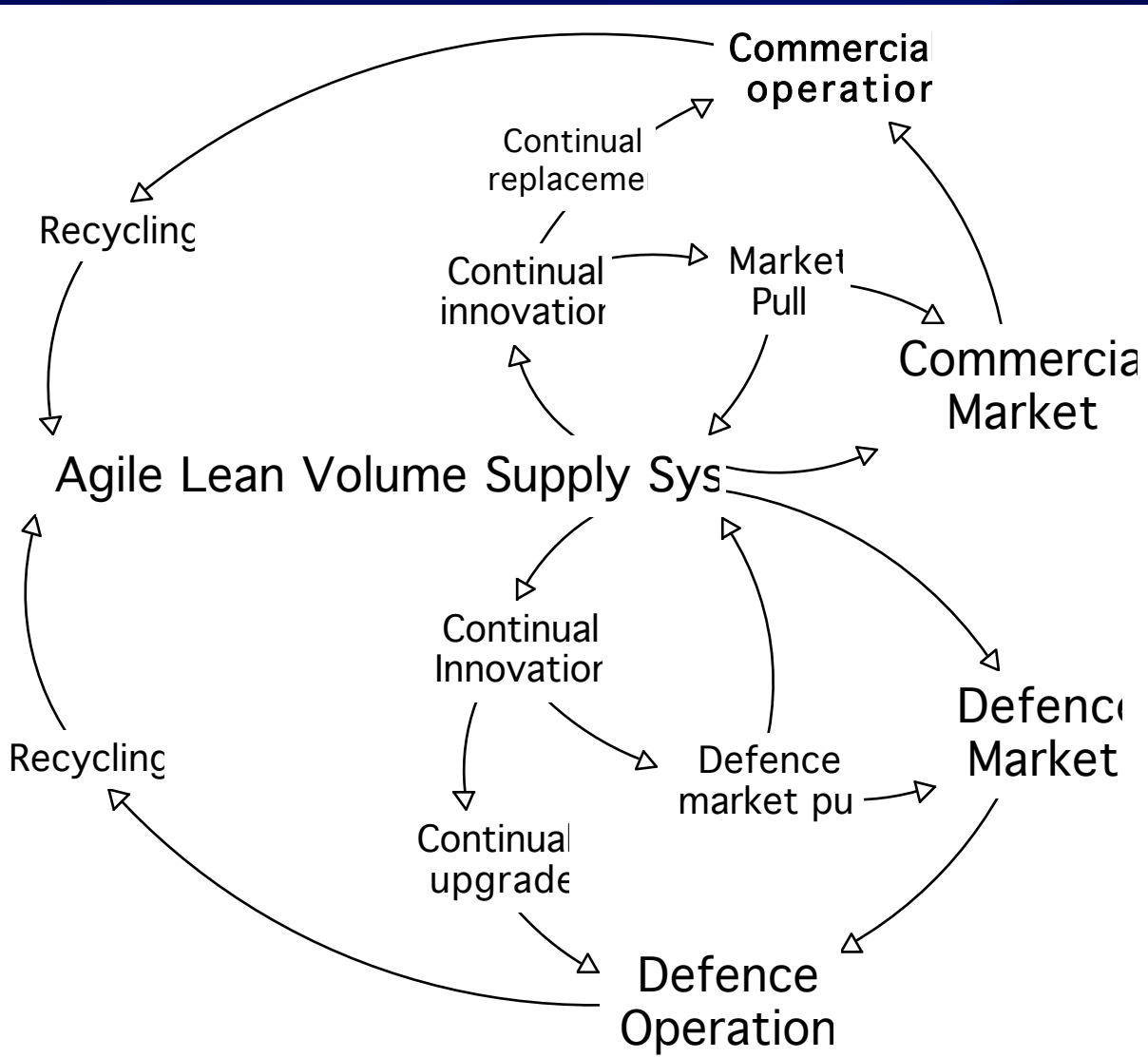
Supply Chain Competition



- Competitive Evolution
- Progressive quality improvement
- Progressive cost reduction

- Constructive competition is *between* Supply Circles,
- ***Not*** between Companies in a Supply Circle—that's *self-destructive!*

Total System Acquisition (TSA) Closure



- To gain closure we must include the consumer—**rate of consumption determines the rate of supply by ALVSS**
- ALVSS needs to operate continuously, else collapse
- Commercially, innovation renders goods obsolescent
  - Creates market pull
- Defence obliged to acquire like a commercial consumer, but of defence products
- Defence no longer major customer c.f. commerce
- …so, economy of scale may dictate combined commercial/defence ALVSS

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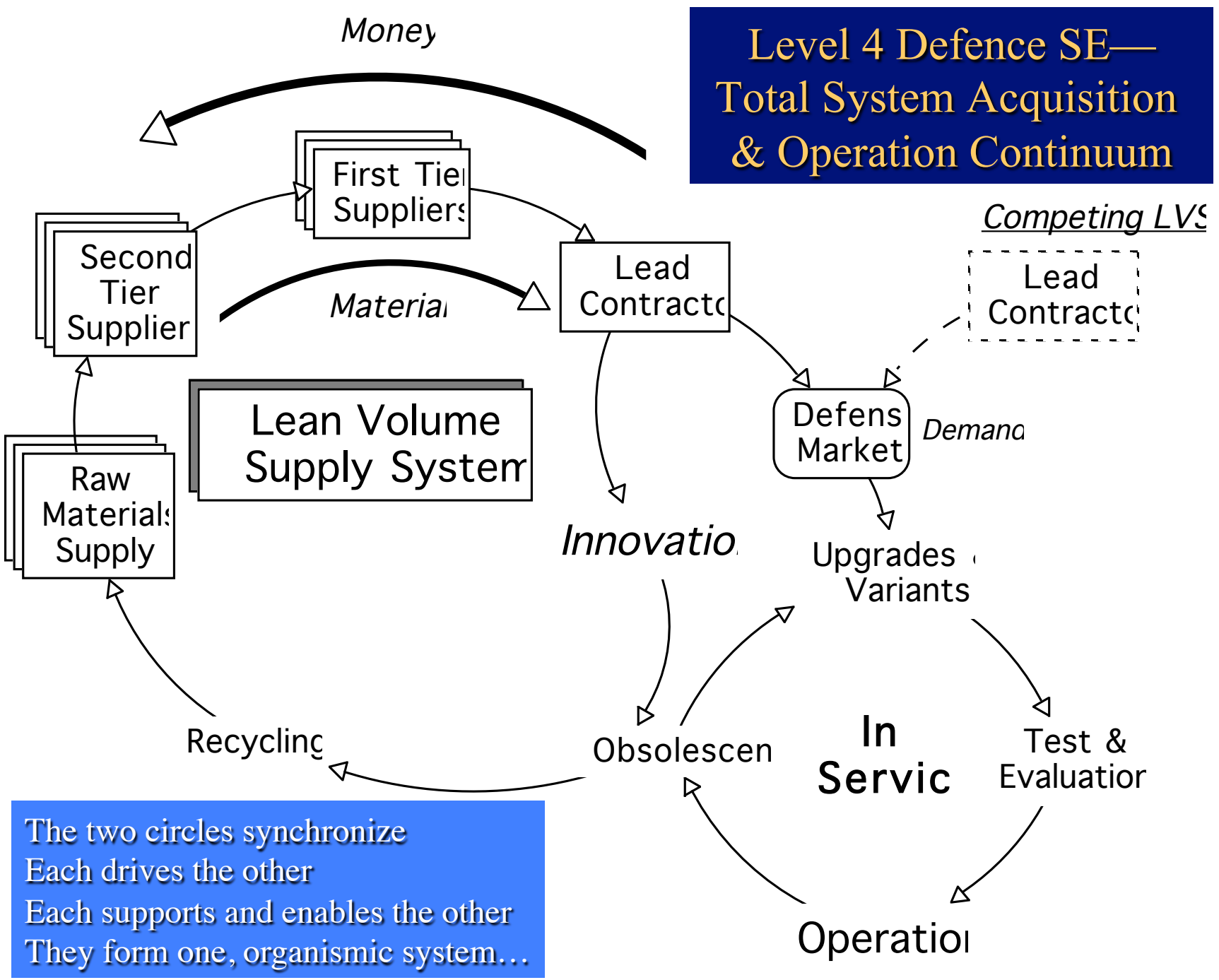
Level 4 Defence SE— Total System Acquisition & Operation Continuum



The two circles synchronize
Each drives the other
Each supports and enables the other
They form one, organismic system…

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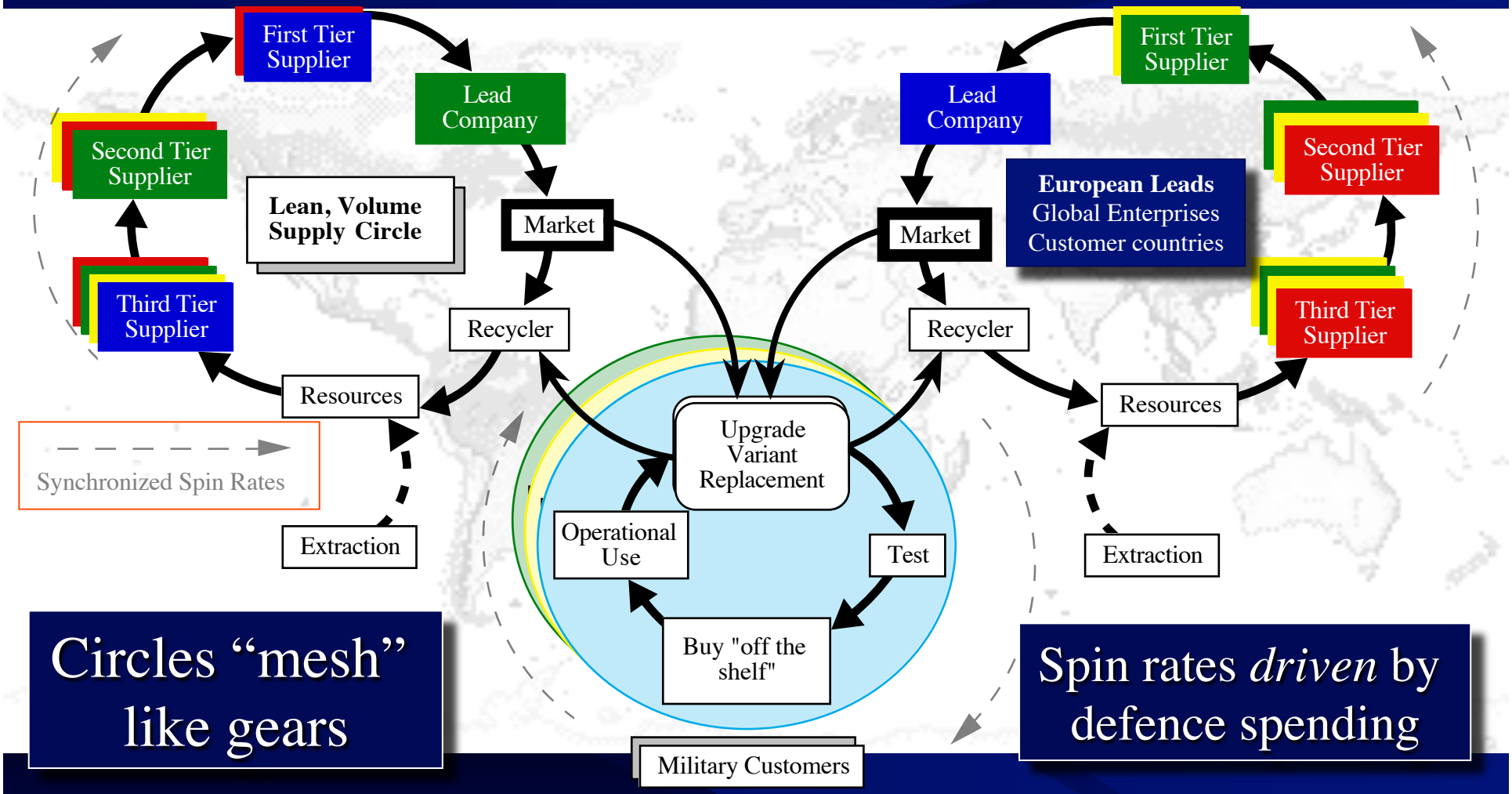
Level 5 Defence SE—Overview



Circles "mesh" like gears

Spin rates *driven* by defence spending

- Wealth Creation in Europe • reduced public spending • reduced taxation
- Socio-economic stability – within Europe + between customer countries
- Balance to US industrial dominance • International Political Stability

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Smart Acquisition Vs. TSA

Smart Acquisition	Factor	Total Systems Acquisition
Customer pays	*Development Cost*	Industry pays
Customer	*Development Risk*	Industry
Trust paper promise	*Customer mode*	Try before buy
Customer	*Financial Exposure*	Industry
Prevents supply circles	*Competition*	Between supply circles
Phased, controlled, slow	*Development Cycle*	Commercial, fast, expert
10-20 years	*Time to market*	12-48 months
Excluded due to long cycle?	*COTS Products*	Included
Customer suppressed!	*Innovation*	Industry inspired
High (low throughput)	*Production Cost*	Low, getting lower *(Kaizen)*
Outmoded at delivery	*Design currency*	Contemporary
Periodic, take out of service?	*Upgrades*	Continual, by industry in-service
Tight, software intensive	*Systems coupling*	Loose for continual upgrade
Periodically improved in service	*Performance*	Continually improved in service
Moderate; 10-20 years	*Lifetime*	Long; c.30-60 years
Integrated Project Team	*IPT*	Integrated Product Team
30/500	*IPT Size*	5/6
Control design & manufacture	*IPT Purpose*	Serve customer, better, faster, cheaper

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Defence Capability Acquisition

…moving up one hierarchy level…

…make the *capability* bespoke…

…with the *platforms* being COTS…

Now, that would be Smart…

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Procuring Defence Capabilities

- Procuring complete defence capabilities:
  - Allows whole capability to be one system…
  - …essential with network centric/enabled solutions
- Allows correct *synthesis* under overarching CONOPS and architecture for capability
  - this opens door wide to COTS
  - avoids "bottom-up" disasters
- Operational networks enable cooperation: capability becomes *organismic* = unified whole
- …and procuring a whole capability to address a whole problem is *holistic*
- Consistent with fundamental systems engineering principles

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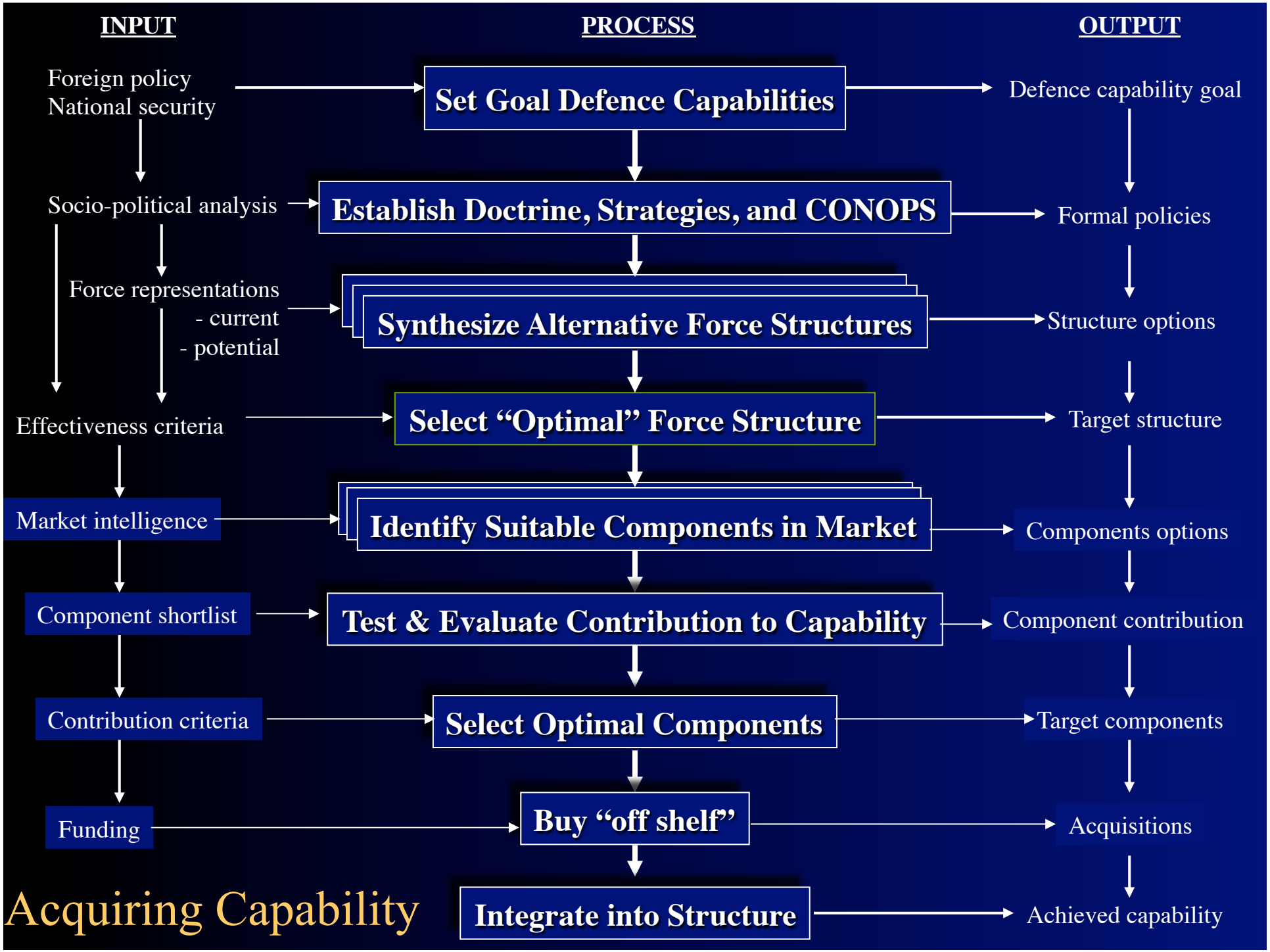
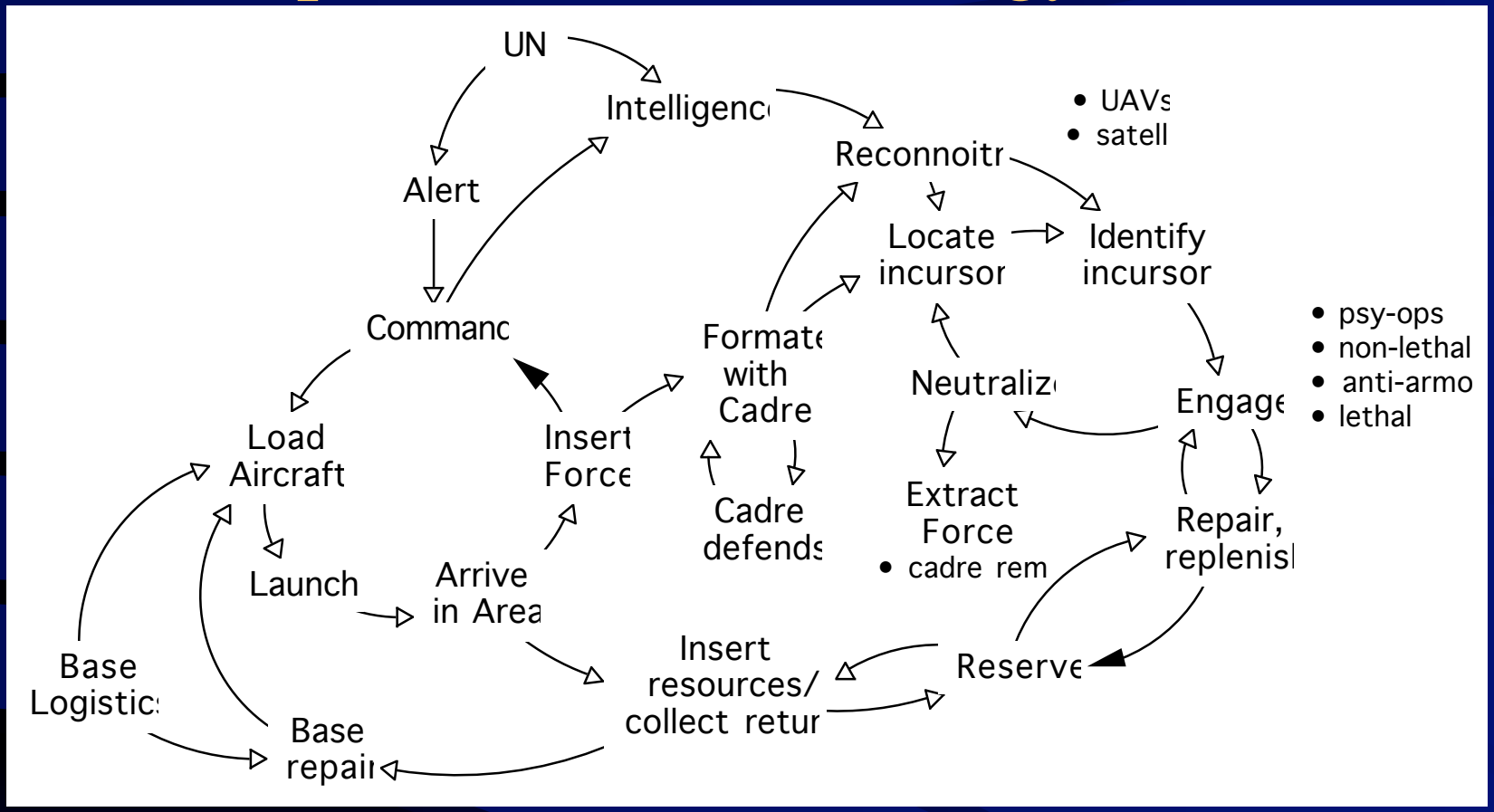
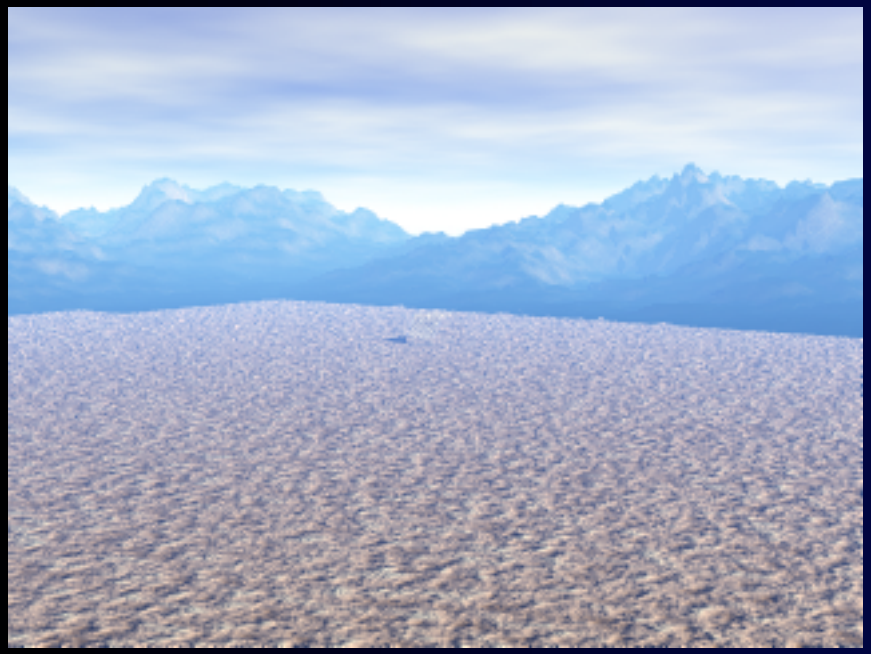
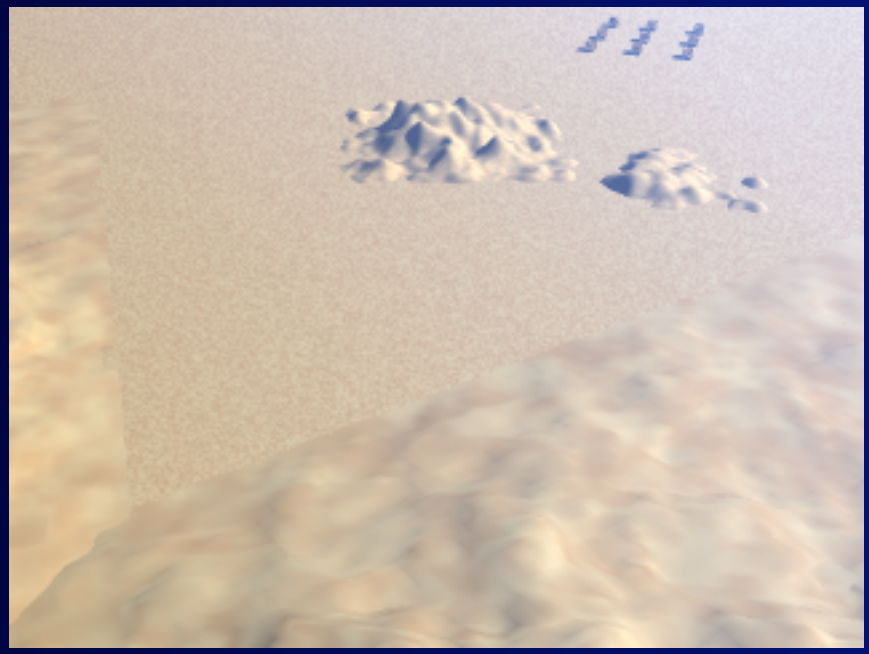

INPUT
PROCESS
OUTPUT
Foreign policy
National security
Set Goal Defence Capabilities
Defence capability goal
Socio-political analysis
Establish Doctrine, Strategies, and CONOPS
Formal policies
Force representations
- current
- potential
Synthesize Alternative Force Structures
Structure options
Effectiveness criteria
Select "Optimal" Force Structure
Target structure
Market intelligence
Identify Suitable Components in Market
Components options
Component shortlist
Test & Evaluate Contribution to Capability
Component contribution
Contribution criteria
Select Optimal Components
Target components
Funding
Buy "off shelf"
Acquisitions
Integrate into Structure
Achieved capability
Acquiring Capability

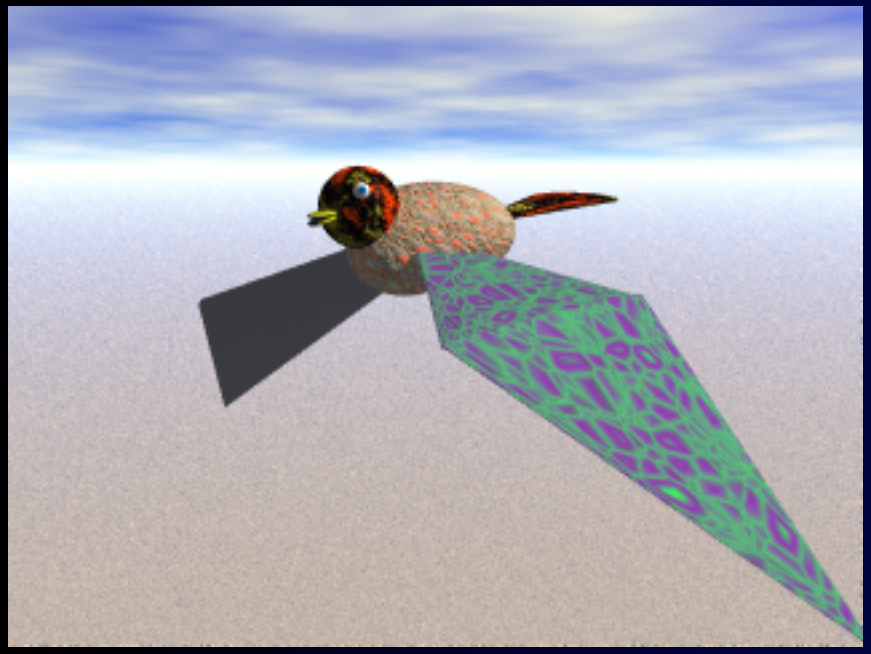
SM Example: Doctrine, Strategy & CONOPS

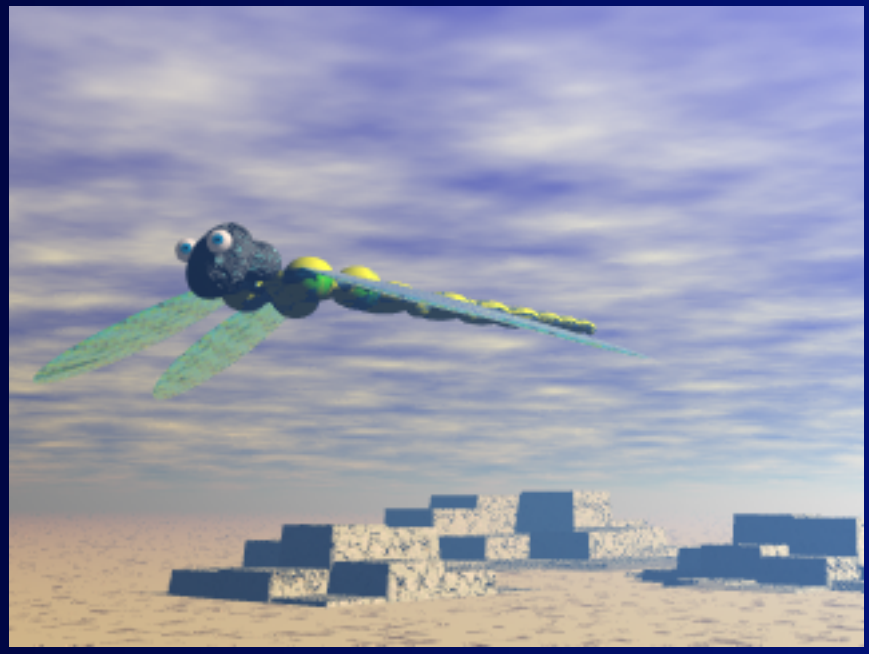


- Global capability, US MLF 2010, open plains, desert and tundra…
- Note continuity of operations: once started, continues until all "incursors" neutralized
- This CLM may be simulated, using a non-linear dynamic modelling tool, to investigate:
  - Time delays • logistics • Effects of operations on reserves, maintenance, and *vice versa*
- Results of simulation may invoke changes to CONOPS
- Final CONOPS defines functional capabilities and architectures for whole force…

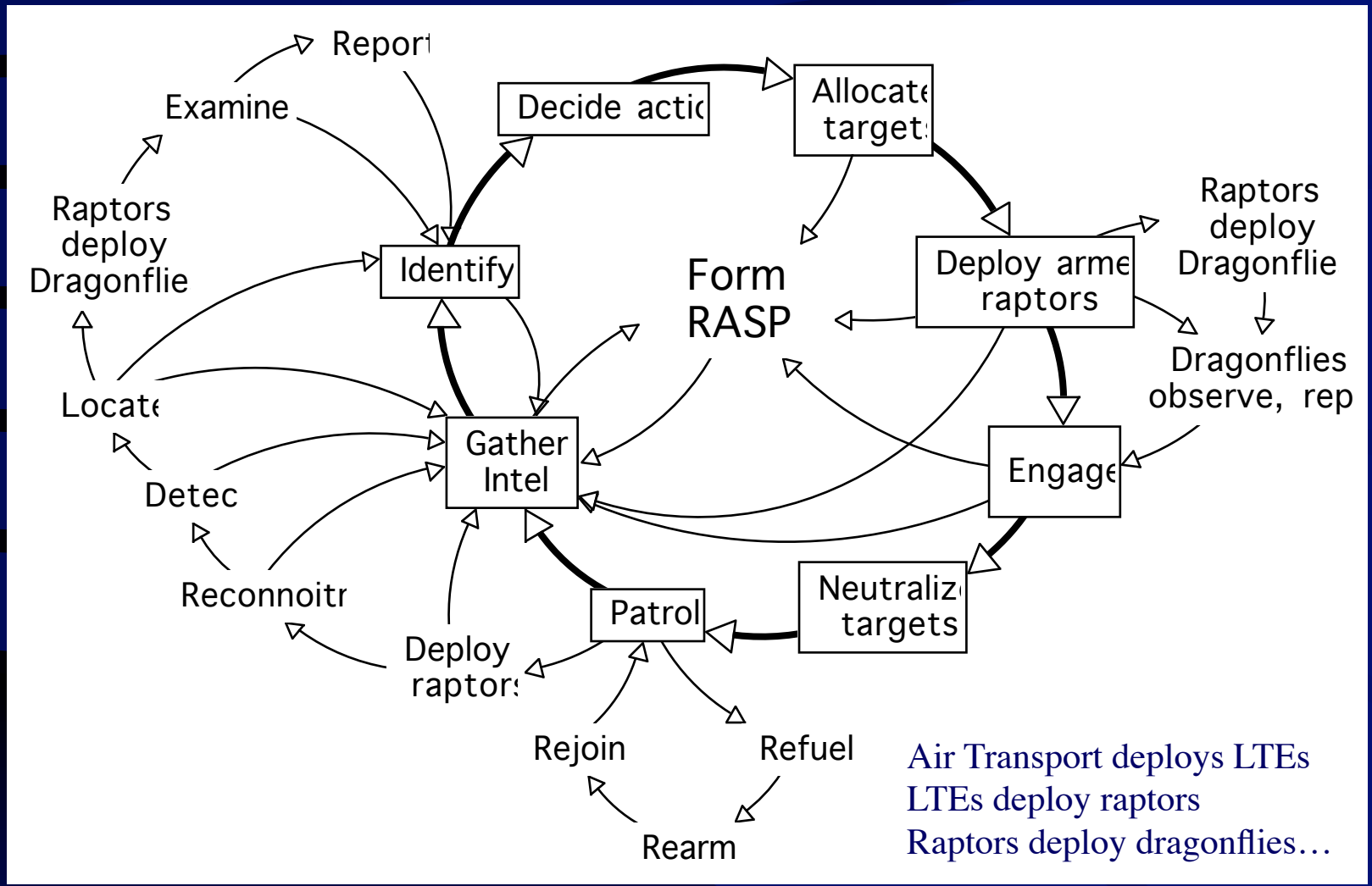








SM: Network-enabled CONOPS



CONOPS presumes that the group, or SWARM, employs network-centric cooperative tactics, with mutually-shared Recognized Air and Surface Picture, plus cooperative automatic target detection, identification, assessment, and target allocation.

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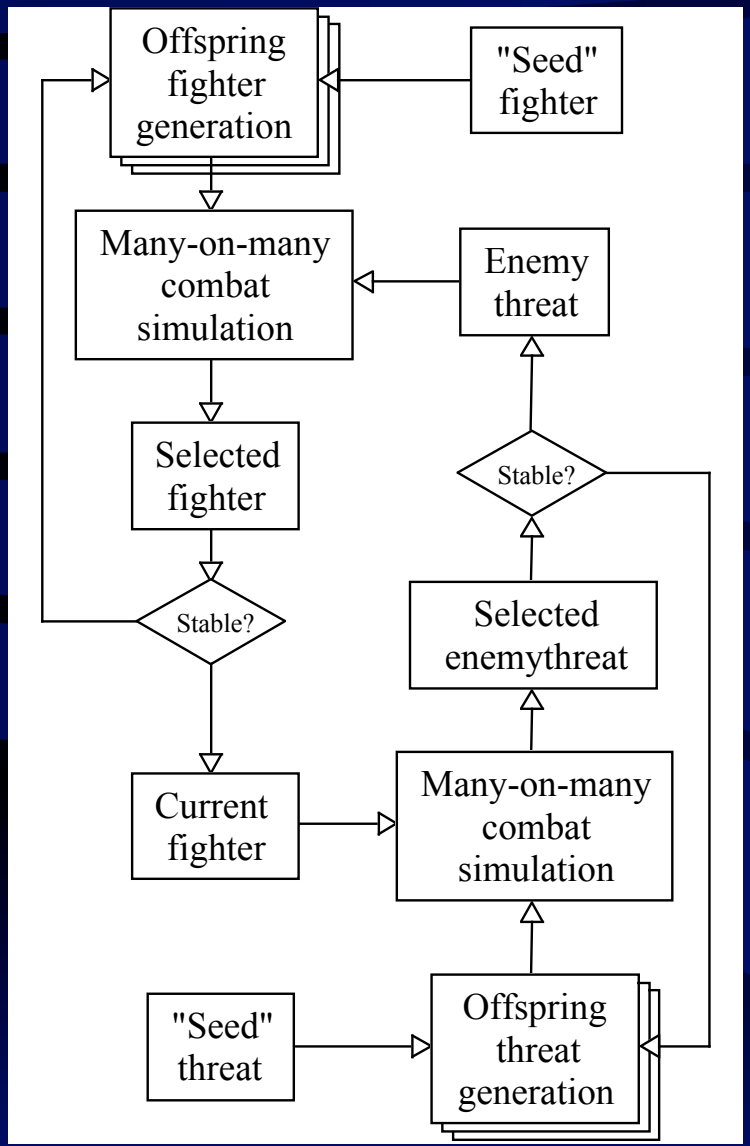
Design Optimization



- Designs may be optimized using cumulative selection
- The diagram shows a method of optimization called “ratcheting”
- First the design in right hand part is frozen
- Design in the left creates offspring, each slightly dissimilar to the parent
- The best performing offspring then breeds
- The two sides swap, and the process repeats…

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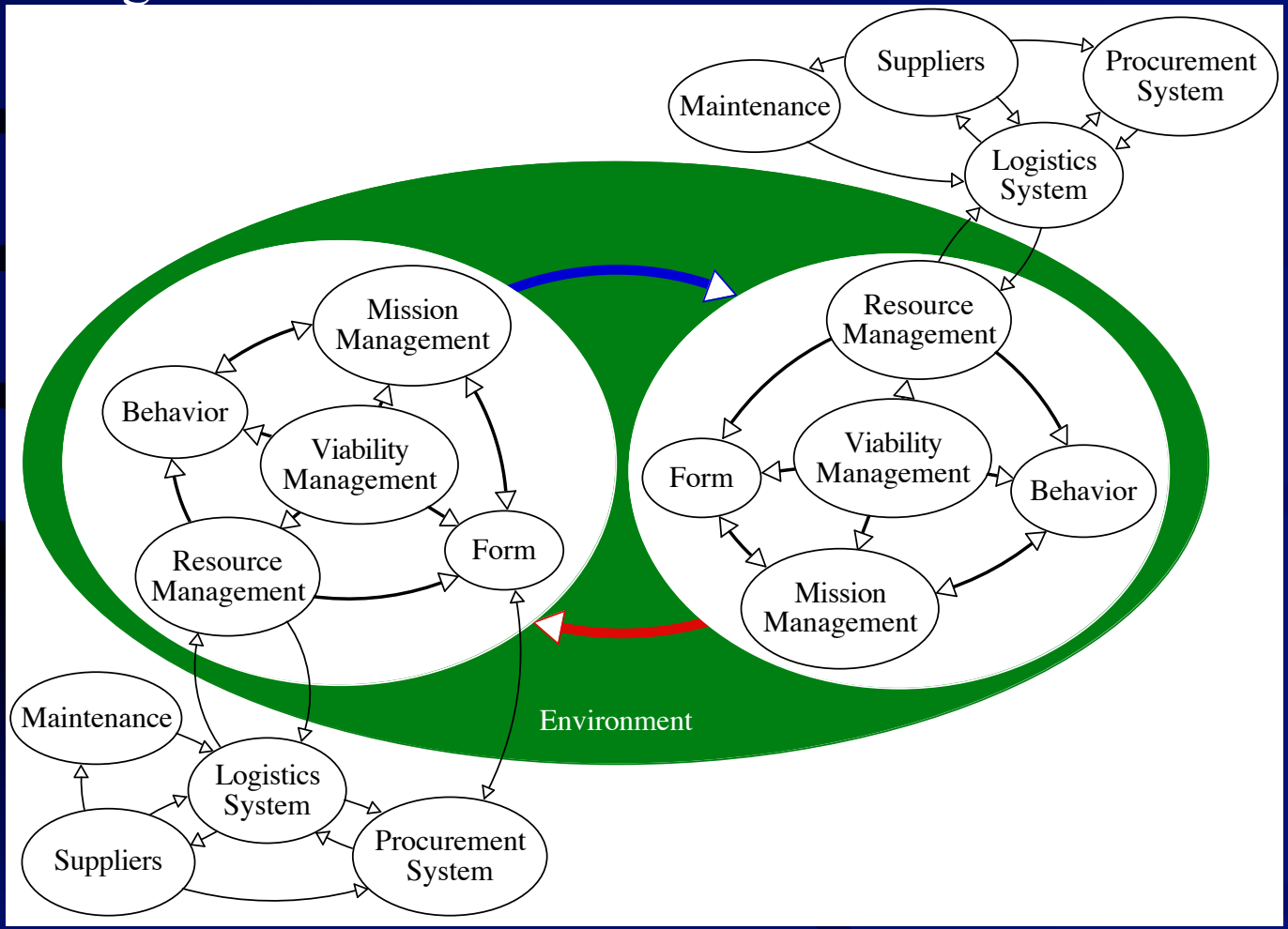
SM: Exploring Dynamic Interchanges

- Two systems engaged in an operational environment
- Each is supported, and its behavior influenced, by supporting functions…



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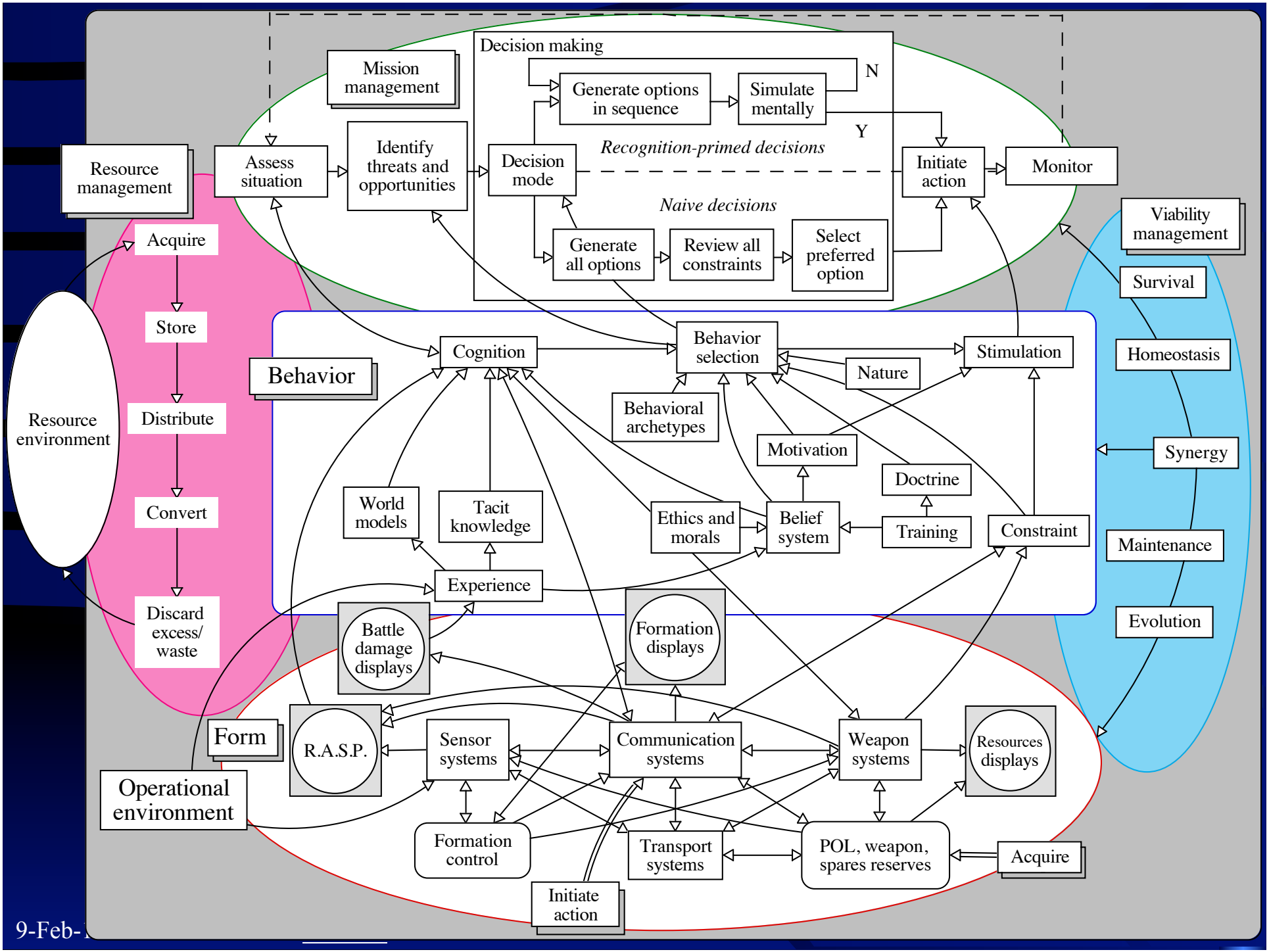
Decision making
Mission management
Generate options in sequence
Simulate mentally
N
Y
Recognition-primed decisions
Naive decisions
Resource management
Assess situation
Identify threats and opportunities
Decision mode
Initiate action
Monitor
Generate all options
Review all constraints
Select preferred option
Acquire
Store
Distribute
Convert
Discard excess/ waste
Resource environment
Behavior
Cognition
Behavior selection
Stimulation
Nature
Behavioral archetypes
Motivation
Doctrine
World models
Tacit knowledge
Ethics and morals
Belief system
Training
Constraint
Experience
Viability management
Survival
Homeostasis
Synergy
Maintenance
Evolution
Battle damage displays
Formation displays
Form
R.A.S.P.
Sensor systems
Communication systems
Weapon systems
Resources displays
Operational environment
Formation control
Transport systems
POL, weapon, spares reserves
Acquire
Initiate action

Conclusions

1. Design whole defence acquisition system along commercial lines - using provable, science-based Systems Methodology
2. Establish a transitional program to move from present bureaucratized approach towards target acquisition system design…
3. Trial commercial-style acquisition of just one full defence capability:
   - free industry to conceive, design, develop, construct, deliver and…
   - support in service…
4. For trial, customer-user states only:
   - requisite capability, CONOPS, architecture, timescales, budget—**not** solution
5. Industry keeps 50% of any price undercuts, but pays for any overprice…
6. …and payments happen after 1 year of successful capability deployment

- Customer-user has nothing to do with any requirements, build standards, COTS or bespoke, progress control, management - nothing!
- Customer-user has everything to do with post delivery operational tests, trials and validations—i.e., thorough "try-before-buy"
- That way, we might just achieve really Smart Acquisition…

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