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Military SpacePlane: Ground Operations Model



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Introduction

- **MSP Ground Operations**
- **Problem Statement**
- **Modeling Considerations**
- **Problem Solving Approach**
- **Venture Evaluation Review Technique**
- **System Data & Analysis**
- **Findings & Recommendations**
- **Summary & POC Information**





Air Vehicles Directorate



Vision



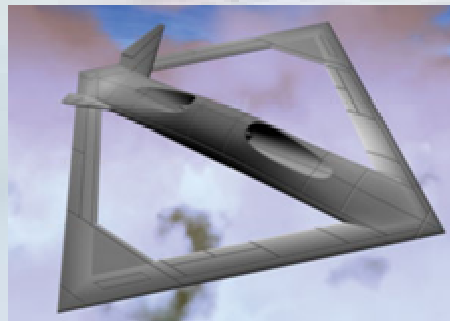
Strike UAVs



Technology Insertion



Long Range Strike



Persistent ISR

NEAR FAR
Provide the Best Air Vehicle
Technologies for
Aerospace Dominance
MID



Space Operations Vehicle



Directed Energy Integration



Advanced Mobility



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Air Force Research Laboratory



Directorate Mission

- **Plans, formulates, and directs science & technology research for military air vehicles exploration and advanced technology development**
- **Orchestrates/executes technology developments in aeronautical sciences, control sciences, and aerospace structures**
- **Integrates systems level air vehicle technologies with other AFRL directorates. Provides technical support for aerospace systems integration**
- **Orchestrates technology development with other DOD and national laboratories, industries, universities, NASA, FAA, NATO, and other foreign research organizations**

MSP

Military Space Plane

MSP is a reusable space taxi for carrying payloads into and from space. A space craft that embodies “aircraft-like” characteristics of current air vehicle platforms



Used for

- **Space Control**
- **Force Enhancement**
- **Space Support**
- **Force Applications**



- **Reusable space delivery and mission operation system**
- **Timely delivery of mission assets to and from space**
- **Multi-mission capable with interchangeable payloads**
- **Short-cycle, rapid mission turn around time**



MSP Modules

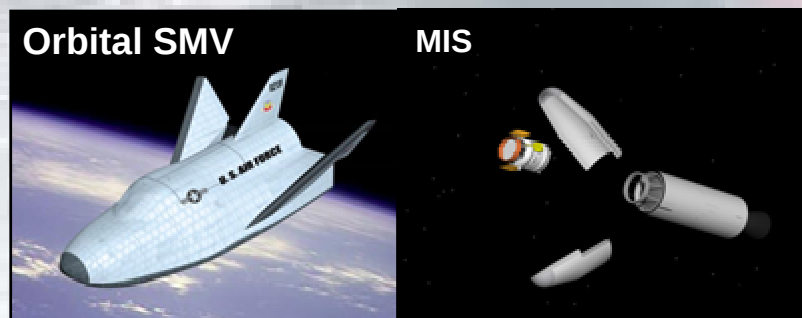


Three Components

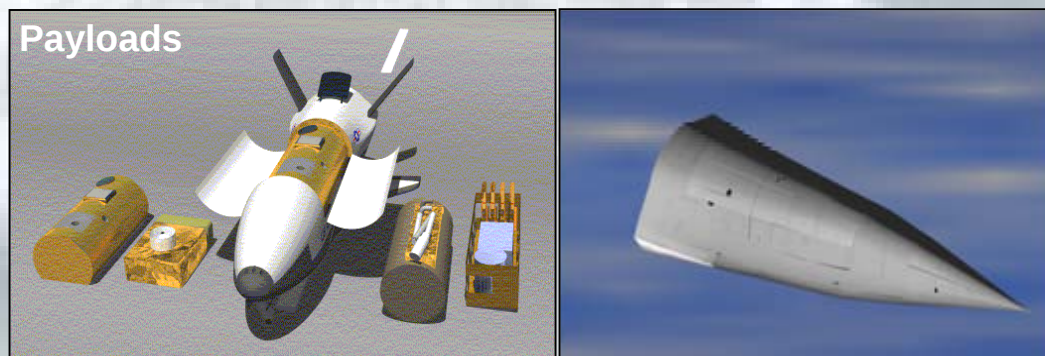
1. Space Operations Vehicle (SOV)
Reusable **Booster**



2. Space Maneuver Vehicle (SMV) and
Various **Upper Stages**

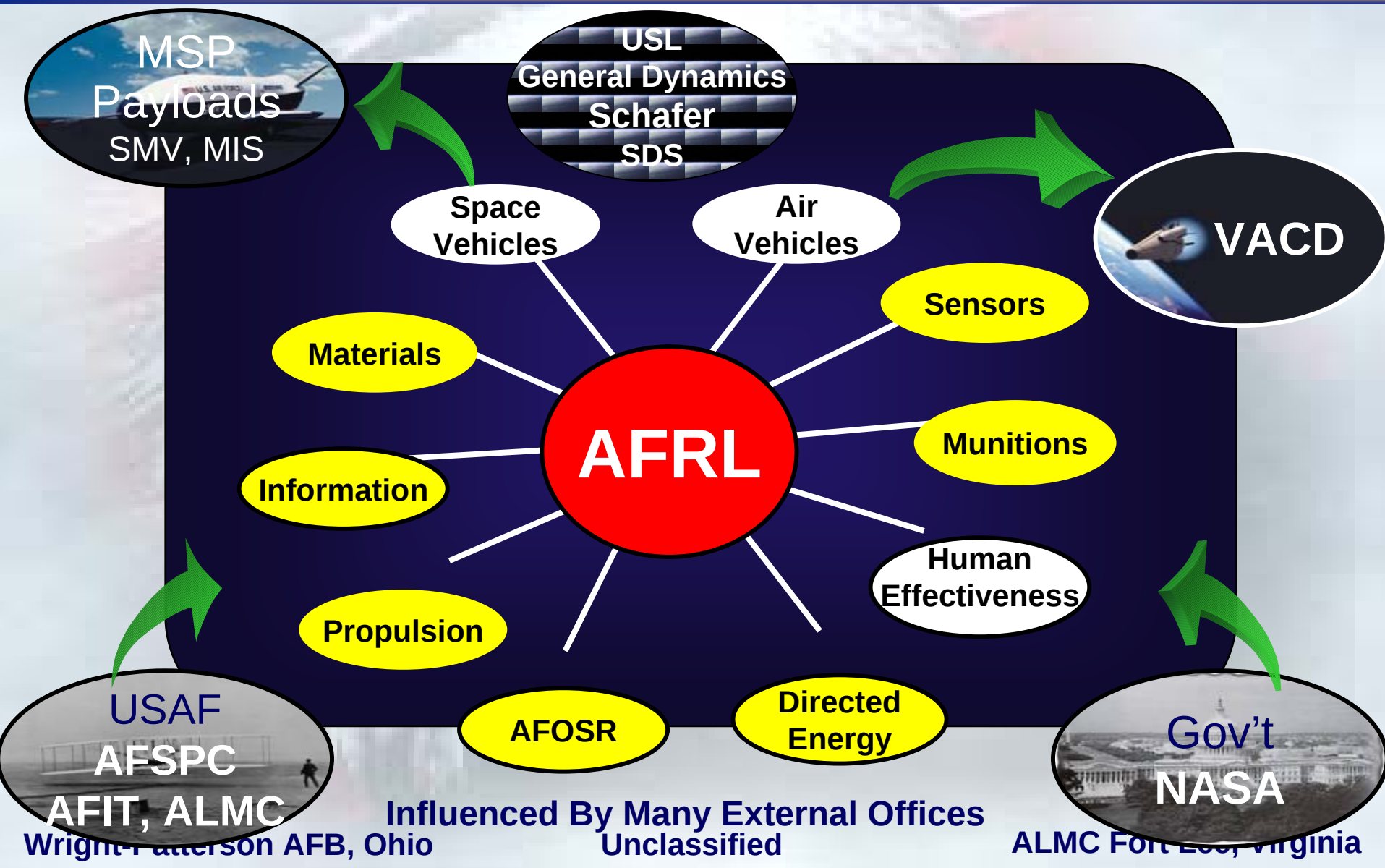


3. Various Operational
and Space
Mission **Payloads**





Coordinating Agencies/Industries



Operationally Response Spacelift Requirements

Operationally Response Spacelift systems must be available and dependable... They must also be reliable, supportable, maintainable and **robust enough to generate required mission rates... capable of meeting required turnaround-times**

Mission Need Statement for Operationally Responsive Spacelift (20 Dec 01)

Need mid/far-term SS capabilities including robust and responsive space lift, rapid satellite configuration/on-orbit initialization; **provide quick-turn, on-demand, assured space access for time-sensitive military operations** (re-position or boost on-orbit assets)

AF Space Command Strategic Master Plan Space Support Roadmap (1 Oct 03)

During periods of war [provide] ... **sortie rate** at least **.33** sorties per day with an objective of **.50** sorties per day; **surge**; **.50** sorties per day with an objective of **1.0** sorties per day. **During periods of war or exercise** [provide] ... **turn times** of **18** hours with an objective of **12** hours; **surge** of **12** hours with objective of **8** hours.

Systems Requirements Document for Military SpacePlane System (12 Feb 01)



Problem Statement



Background

A key element in space sortie generation continues to be the ability to reduce ground operations turnaround times

Problem Statement

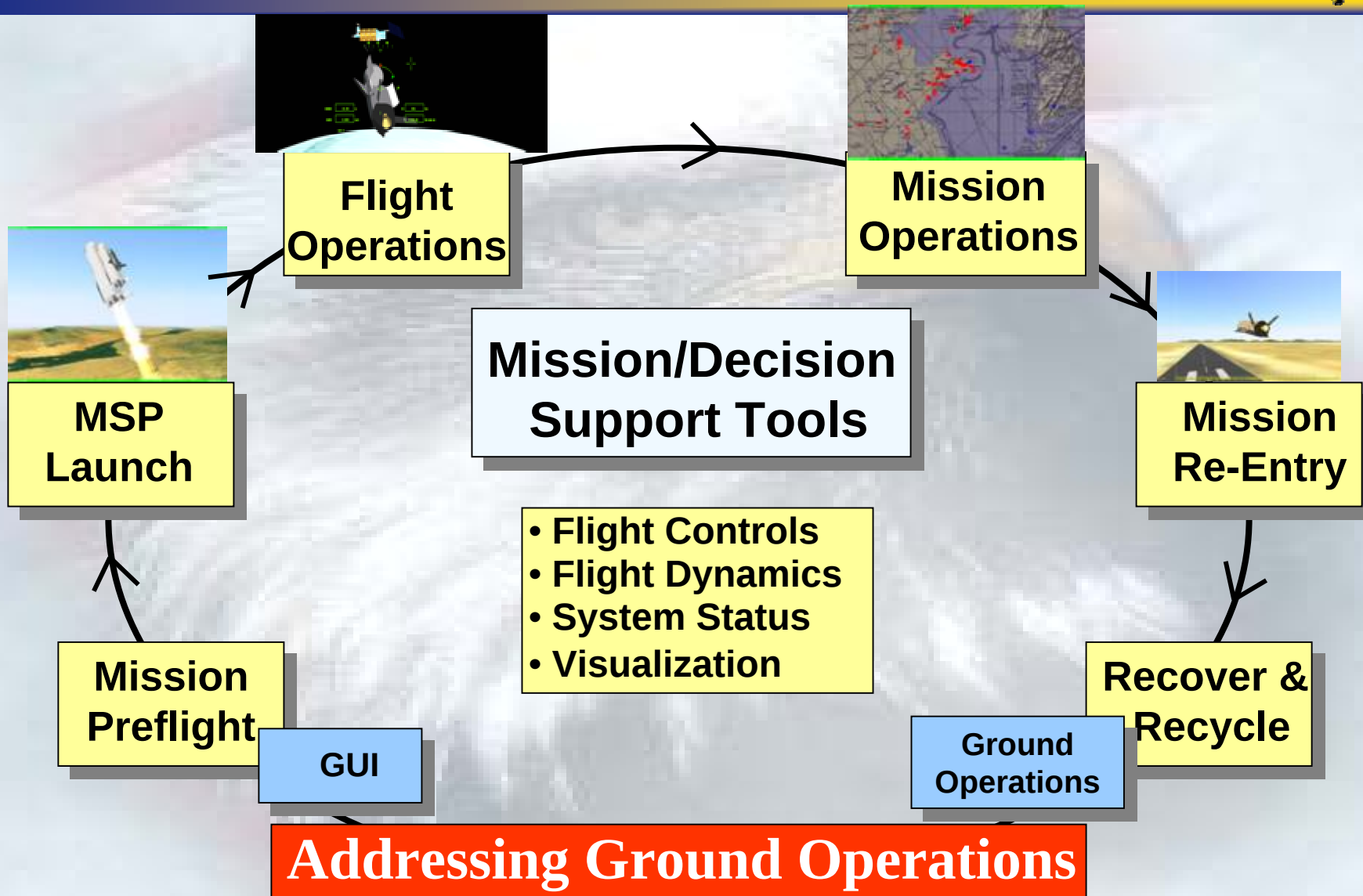
While there is data for real systems, there is little basic research on ground operations for experimental military spacelift vehicles. Turnaround information shortfall applies to **processes** based on engineering designs **and** on estimated **data** useful to a spacelift operation center (SOC) responsible for command and control of spacelift platforms



SAVMOS



Space Access Vehicles Mission & Operations Simulation

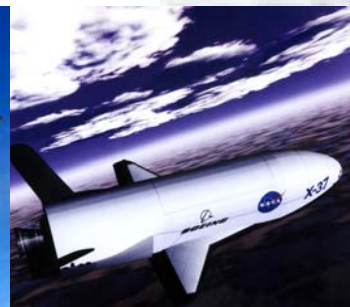




Vehicle Comparisons



System →



MSP

System:	Space Shuttle	SpaceShipOne	X-37 Vehicle	B-2 Bomber	MSP
Mission:	Operational	Experimental	Experimental	Operational	TBD
Crew:	Manned	Manned	Unmanned	Manned	Unmanned
Size & weight (Payload):	Large	Small	Small	Large	Variable
Sortie Rate:	180+ days	2 < weeks	N/A	8 < hours	Goal: 8 < hrs



Ground Operations (Mission Ops)



Large and Manpower Intensive



Notional SAVMOS Facility & Crew Size



- Minimized crew size (operational manning)
- Reduced facility size (footprint)
- Reduced cost



Major Ground Operation Activities



Mission Return Phase 1

- Safe-making & moving
- Health assessment
- Post-mission Inspecting
- Payload removal
- 3 phase maintenance
- Flight Storage

Sortie Generation Phase 2

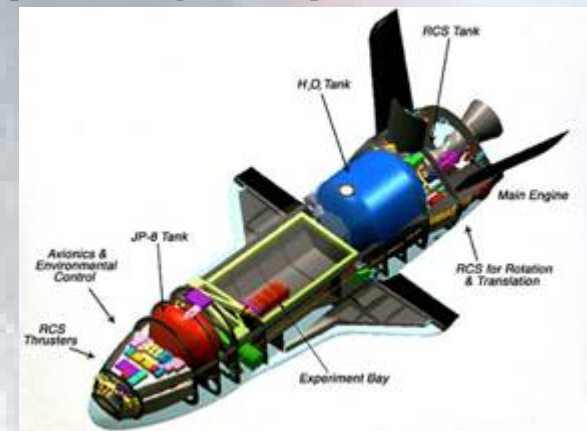
- Preflight ops checks
- Payload instantiation
- Connections & assembly
- Transport to pad
- Fueling operations
- Pre-launch preparation



Modeling Considerations



- Which operations to model (sequence major event)
- Size and scope (Fidelity) of model
- Sources of modeling information (B-2, Cape, Dryden)
- Comparative space-air data
- Data types and acquisition
- Criteria for computer model selection
- Model construction of ground operations
- Experiments with Ground Ops simulation
- Development of tools and algorithms





Levels and Scope of Modeling



- **Spaceport Level**
 - Entire space facility (all operations)
 - Every aspect of resources (A to Z)
 - Continuous flow (multi-ship operations)
- **Operations Level**
 - Mission operations vs. ground operations
 - Single cyclic flow of MSP(s)
 - Resources dedicated to sortie generation
- **Engineering Level**
 - Single ship high resolution activities
 - Craftsman level of operations
 - Detailed estimates (e.g., tile replacement)

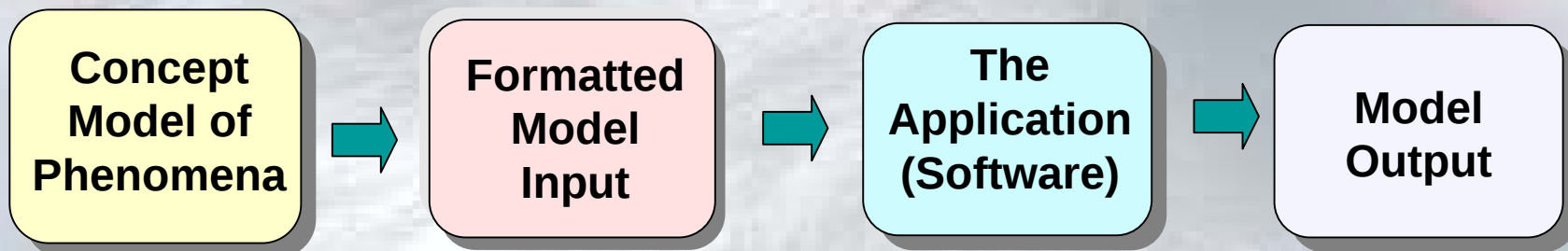




Problem Solving Approach



- Perform phenomena research
- Determine processes and data sources
- Build a conceptual spacelift turnaround model
- Research COTS/GOTS software



- Select software and data for simulation
- Experiment with the ground ops simulation
- Analyze results and seek validation
- Refine the model and further develop tools



VERT

Venture Evaluation & Review Technique



One Ground Operations Modeling Approach

Dr. George Huntley

Army Logistics Management College



ALMC

Army Logistics Management College



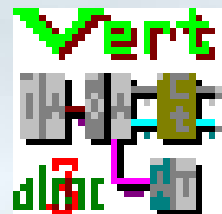
- Trains US civilians, military, and US allies
- Major teaching subjects and consulting areas:
 - Systems Engineering (ORSA/MAC-I, Cont. Education, STS)
 - Logistics Courses (CLC3....)
 - Defense Acquisition Training (Mil. Acquisition Mgt)
 - Military Operations Research/Systems Analysis
 - Decision Risk Analysis for Engineers
- Resident, Onsite, Web and DL Instruction
- 50th Anniversary in 2004
- Trained over quarter-million DoD students

ALMC at Fort Lee, Virginia (www.almc.army.mil)





VERT



VERT is a network computer simulation “Engine”

- Builds greatly upon PERT/CPM but is stochastic
- Developed by Gerald L. Moeller at US Army’s Rock Island Arsenal, Illinois & others since 1970s
- Used for **describing** & analyzing **new & risky** projects
- Uses time, cost, performance, & probabilities to evaluate alternatives
- **Free** for US Govt use & **easy** to Learn
- **Proponent:** US Army Log. Mgt. College, Ft Lee, VA



General VERT Use



Great for analyzing small to moderately complex projects

- **Historically** used to
 - Develop new weapons systems
 - Generate independent cost estimates
 - Effects of chemical demilitarization
 - Estimate logistics problems of simultaneously fighting several limited world conflicts
 - Plan reactivation of “Mothballed” facilities
 - Other efforts (reliability, design, safety)



VERT Strengths & Limitations



- **Strengths**

- Graphical formulation converts to arcs and nodes with data
- Easy to learn, formulate model, and instantiate
- Provides quick turn simulation runs
- Automatically provides useful statistical output
- Price is A-OK, ALMC is sponsor

- **Limitations**

- Can be unwieldy with gigantic projects
- NO “looping back” to previous part of network
- PC Version 3.7 limited to 350 arcs/200 nodes/1000 iterations
- Only 20 internal/10 terminal node, 20 slack histograms
- PC Version needs VV&A on queue and time phasing
- Minimal “user friendly” features (DOS like)





VERT 101



Arcs are Activities



From
Node

Tying your shoe

Prob of success

To
Node

Time(T)/Cost(C) /Performance(P) Estimates

Arcs not Orcs

Nodes are conditional branch points or decision logic points

Start

Terminate

And

Or

Compare
T/C/P

Waiting
Queue

Some Example VERT Nodes

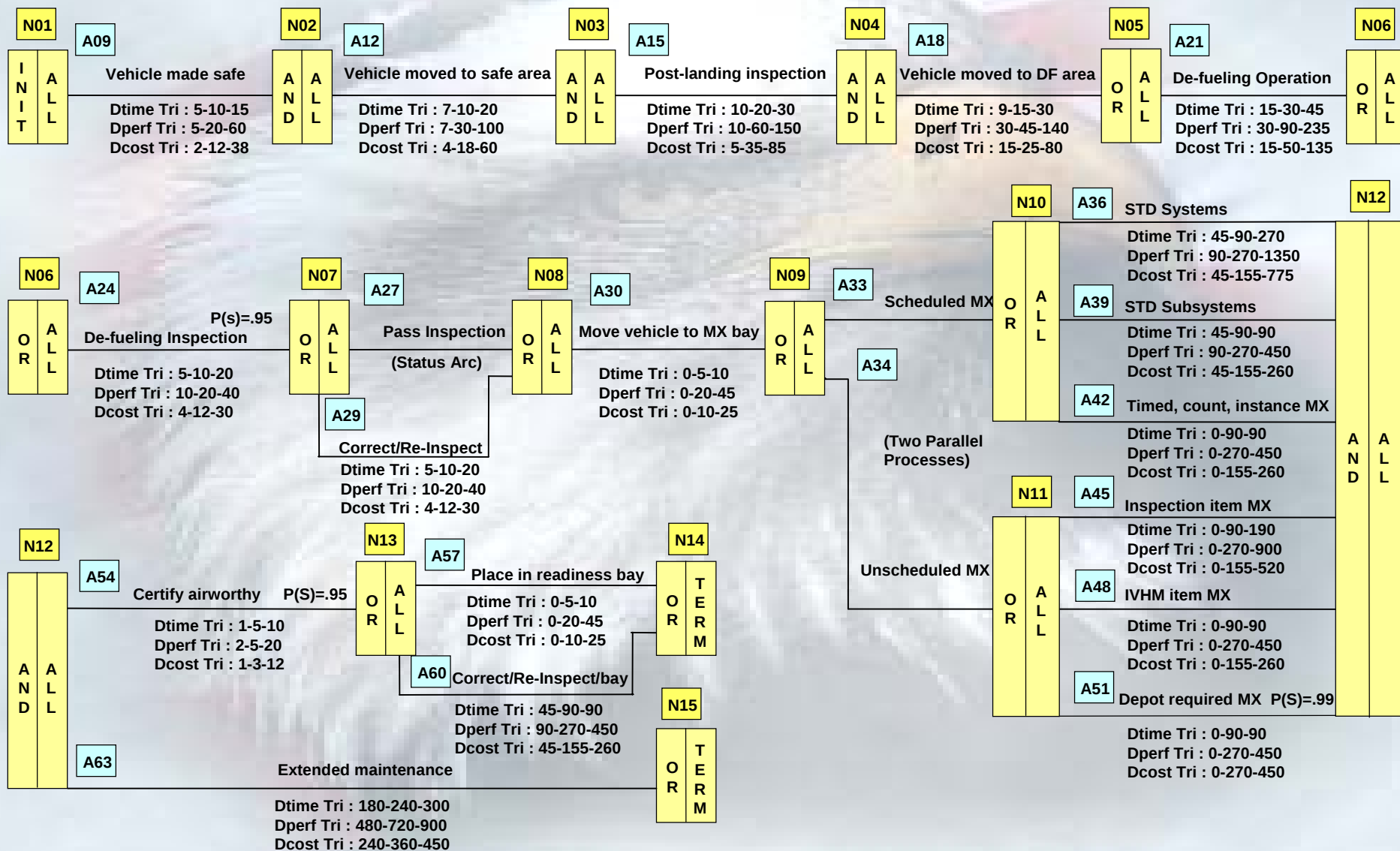
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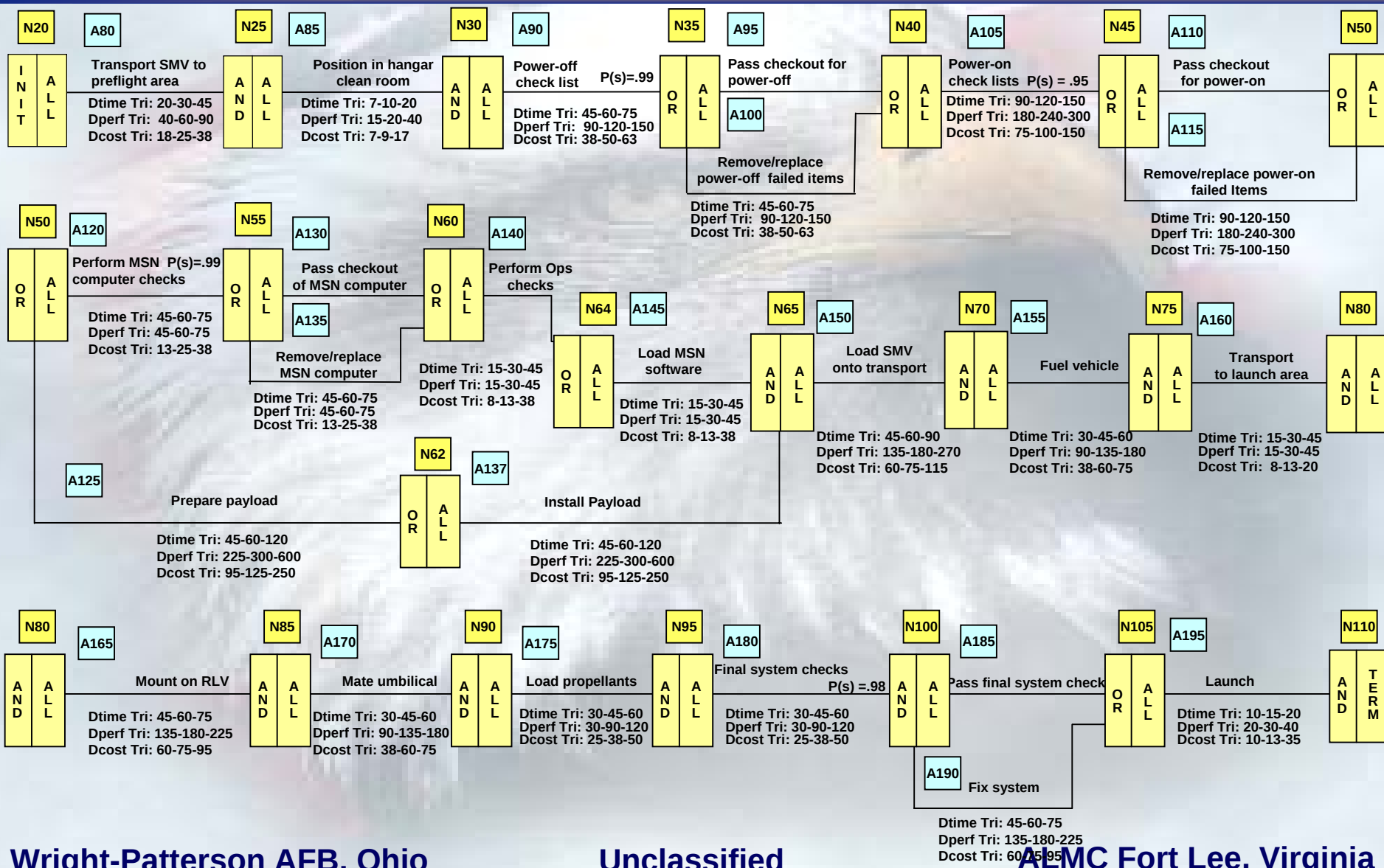


Post-Landing





Pre-Launch





Network Results



Post-Return	Arc/Nodes	Key Probabilities (Notional)	Hour	%
Sch/Unsch MX	21 Activities	.95 De-fuel ops	4.45 *	98
MX Delay	15 Decision Points	.99 No depot MX .95 Cert. inspection	7.86 *	02

Pre-Launch	Arc/Nodes	Key Probabilities (Notional)	Hour	%
Preparation, test, & payload	25 Activities 21 Decision Points	.95 Power off check .95 Power on check .99 Computer check .99 Final System check	12.2 *	100

Post-Return thru Pre-Launch	Arc/Nodes	Key Probabilities (Notional)	Hour	%
All activities * Results are from Notional Inputs	47 Activities 34 Decision Points	Same probabilities as above	16.6 *	100



Findings & Recommendations



- **Findings**
 - Large amount of time devoted to moving, racking, and stacking
 - Small Prob of failure results in dramatic decreases in time & cost
 - Payload preparation has to be a parallel activity (racks)
 - Goal is to avoid depot maintenance delays (spares)
 - Estimates employed in this draft are highly optimistic
 - Model assumed unlimited use of working spaceport resources
- **Recommendations**
 - Continue work on validation of changing processes (TPS, IVHM)
 - Obtain better data on maintenance tests and durations
 - Move to a more sophisticated computer model when spaceport and vehicle operational data becomes available

Points-Of-Contact



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