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***The Analytical Process Used to Develop Military
Utility-Based Architectures for the Air Force
Space Command's
Integrated Planning Process***

**Mr Danny Mellott
Ms Joyce Stivers
Mr John Tindle**



Agenda

- **AFSPC's Integrated Planning Process (IPP)**
- **Problem Description**
- **Revised Analytical Process**
- **Model Descriptions**
- **Model Integration**
- **Conclusion**



IPP Defined

- An iterative process to evaluate and refine the objectives and tasks of assigned Air Force Mission Areas and functions
- Identifies deficiencies in mission and functional areas caused by changes in national military strategy, global political-military threats, and fiscal constraints
- The foundation for requirements generation and the acquisition process
- Conducted in four stages
 - Mission Area Assessment (MAA)
 - Mission Needs Analysis (MNA)
 - Mission Solutions Analysis (MSA)
 - Integrated Investment Analysis (IIA)
- Relies heavily on modeling and simulation (M&S) to evaluate operational support tasks that support a military strategy and objective

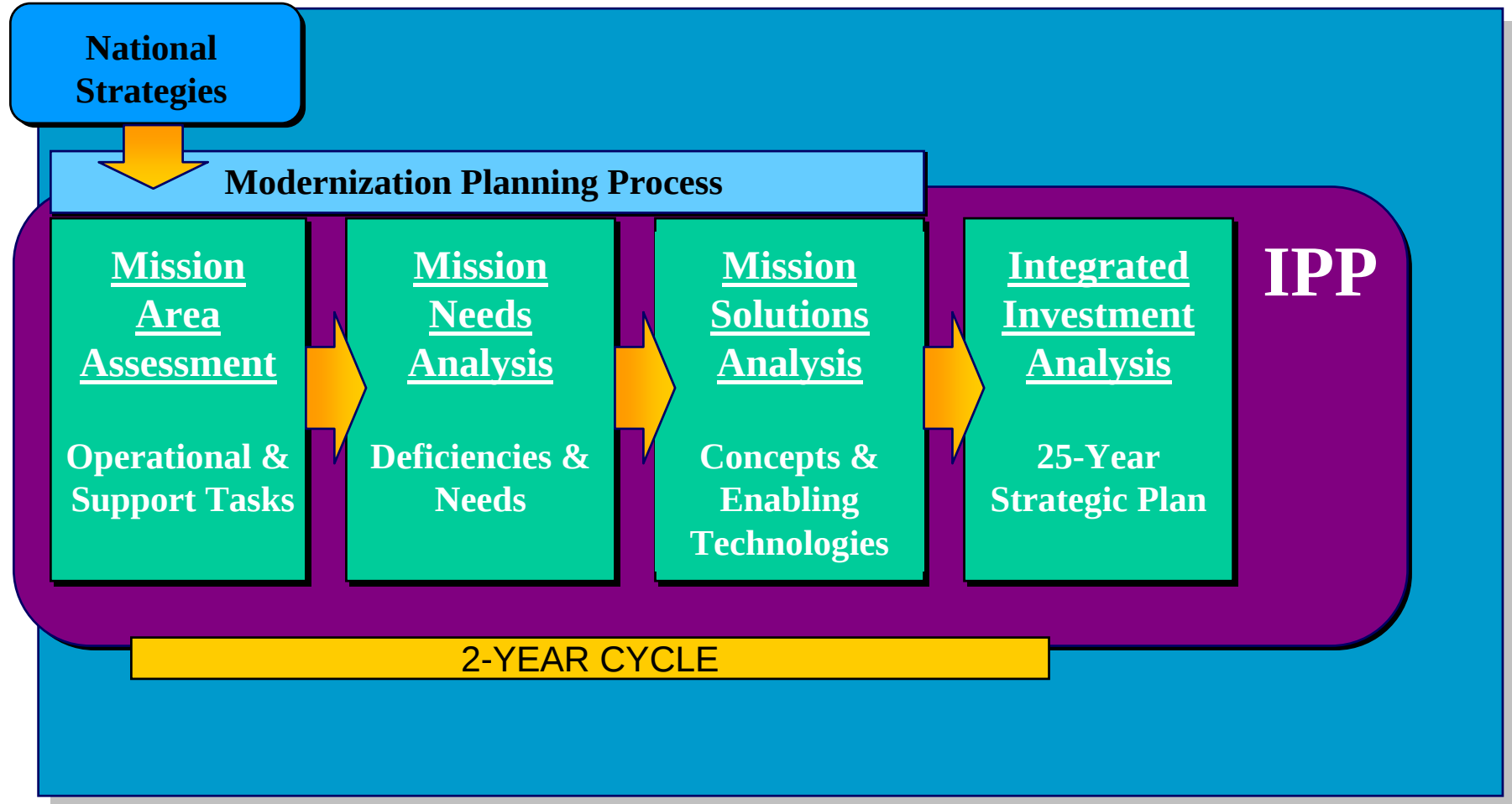


IPP Goals

- **PROVIDE MAXIMUM SUPPORT TO THE WAR FIGHTER**
 - Identify the best architecture (family-of-systems) that will provide what the war fighter needs
 - Provide the guidance for changing doctrine, tactics, training, procedures, and investing dollars for force modernization to achieve the combat capability needed for the future
- **INFLUENCE Program Objective Memorandum (POM) DECISIONS**
- **PROVIDE ANALYTICAL RIGOR to identify the best architecture for POM deliberations based on:**
 - Minimize task coverage shortfall
 - Maximize total task coverage
 - Minimize total spending
 - Minimize budget overspending
- ***MAXIMIZE MILITARY UTILITY FOR THE WAR FIGHTER***

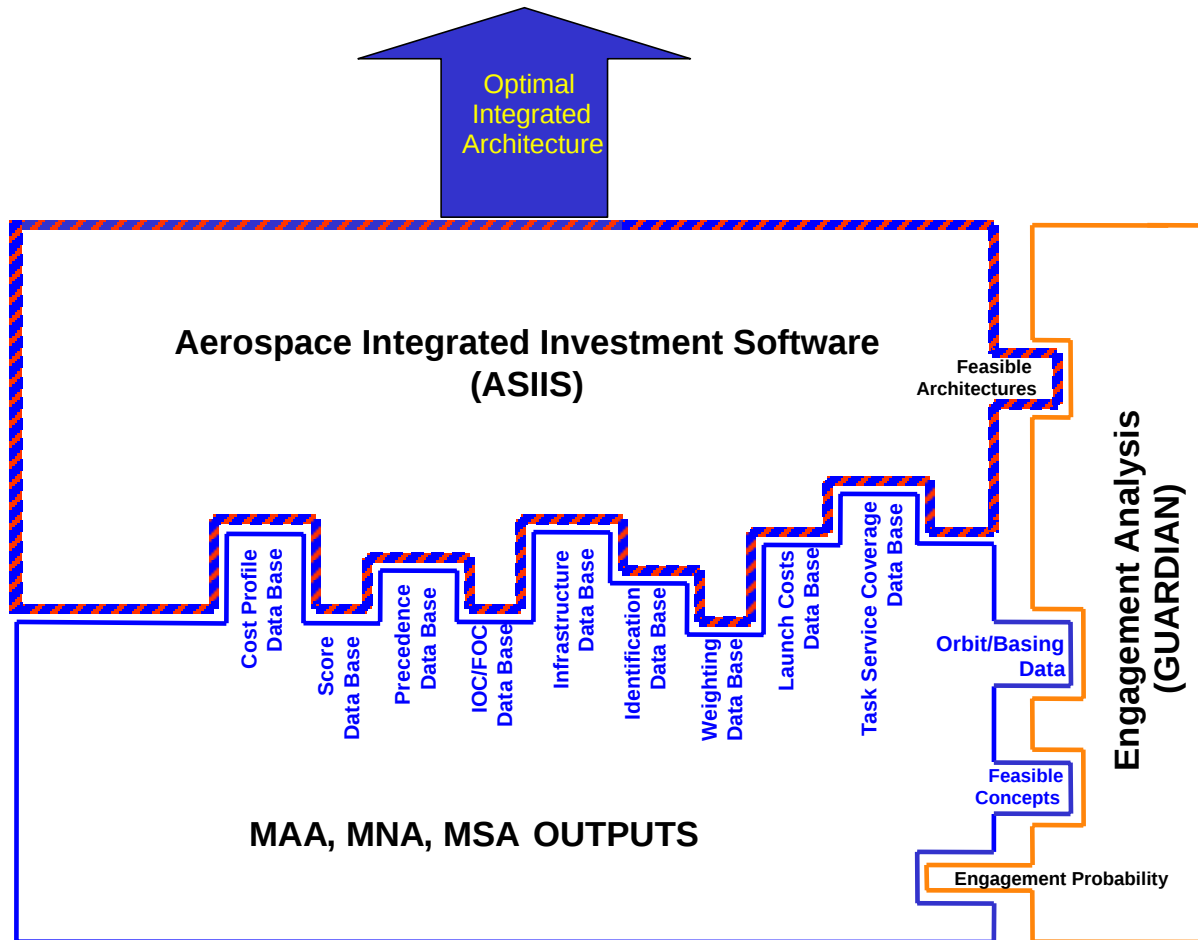


IPP Overview





Integrated Investment Analysis (Prior to FY06 POM)





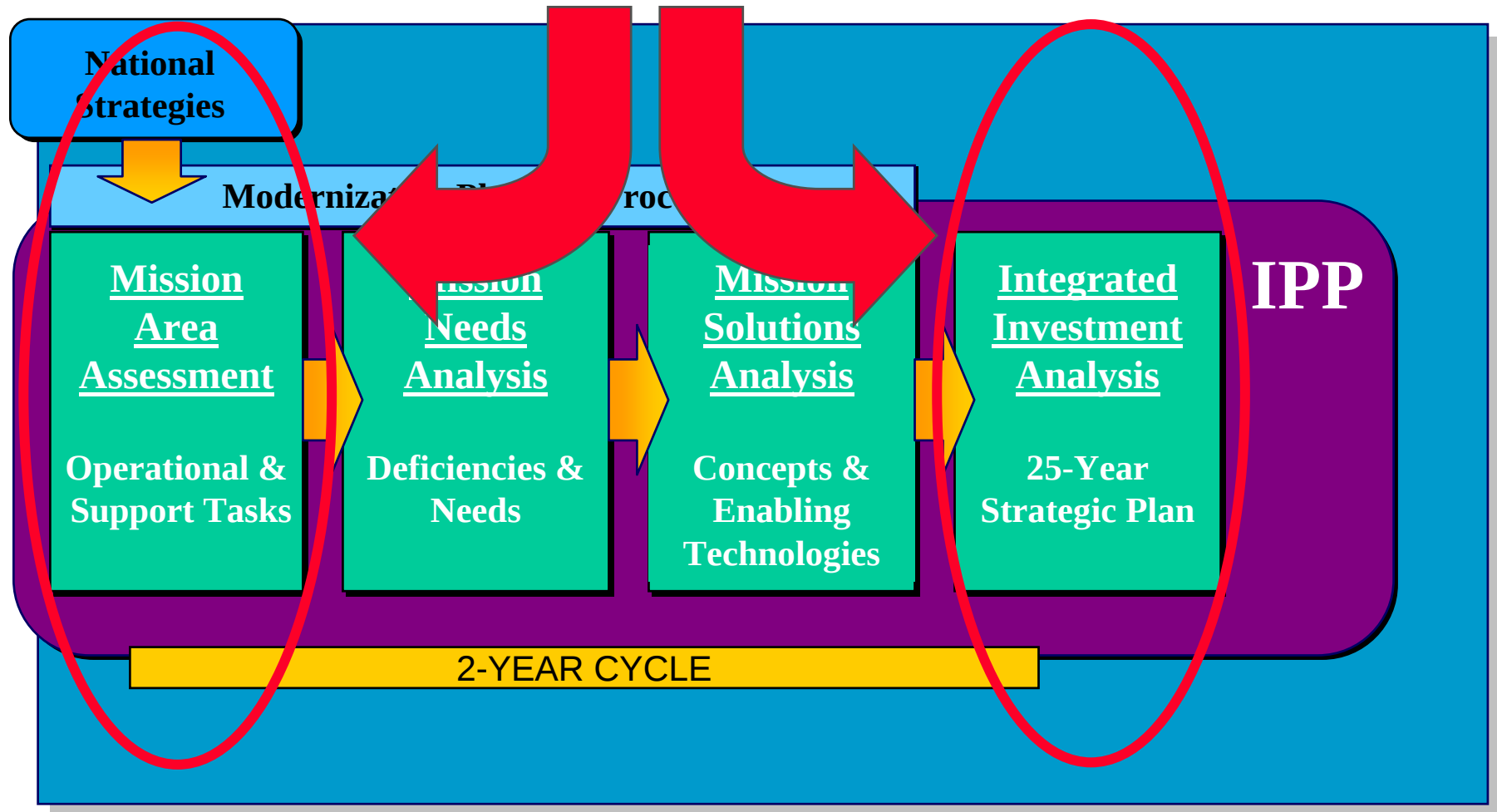
Problem Description

- Prior to FY06 budget build, AFSPC relied solely on the Aerospace Integrated Investment Software (ASIIS - formerly SCOUT) to generate integrated architectures (family-of-systems) in Integrated Investment Analysis (IIA) phase
- *No true measure of military utility generated*
- AFSPC IPP Pathfinder effort created to explore new analytical methods – starting with Counterspace mission area



Revised IPP Analytical Focus

Process Focus Areas





Mission Area Assessment (MAA) Analysis Description

- Value hierarchy developed in **Hierarchy Analysis Tool (HAT)**
- MOEs/MOPs/Metrics defined
- Developed utility curves at MOP-level
- **Weights for value hierarchy developed using Lightning campaign model**
 - **RT-2 Scenario**
 - **OCS weights derived directly from Lightning metrics (ISR, Comm, Nav, Wx)**
 - **DCS weights required translation from Lightning metrics to Threat systems (RF, KE, DE – High, DE – Low, CNA, Physical, HAND)**
- Alternatives scored against MOPs
- Sensitivity analyses conducted

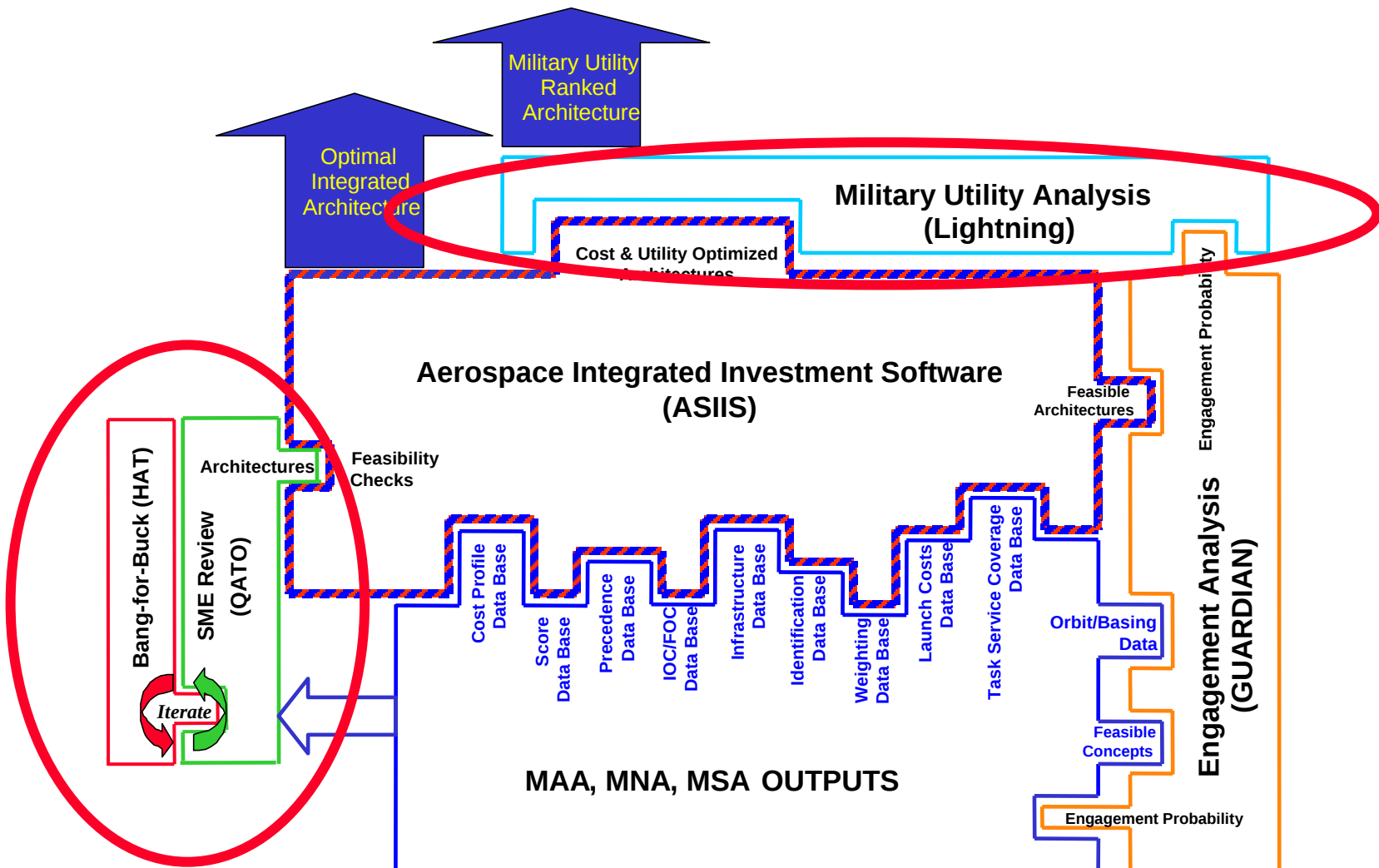


Integrated Investment Analysis (IIA) Description

- **Candidate architectures identified in ASIIS**
- **Architectures run in the Quick Automated Tool for Optimization (QATO) to visually depict, modify, and conduct comparison of architectures by task effectiveness and cost**
- **QATO output modeled in the Hierarchy Analysis Tool (HAT) to assess military utility and provide architecture “bang-for-buck”. HAT also provides recommended system changes to the architecture to improve performance based on Pareto optimality**
- **Changes iterated through QATO to ensure revised architecture meets budget/performance constraints**
- **Iterated architecture run in ASIIS to ensure feasibility**
- **Final architecture modeled in Lightning to provide military utility**



Revised Integrated Investment Analysis





Analysis Tools

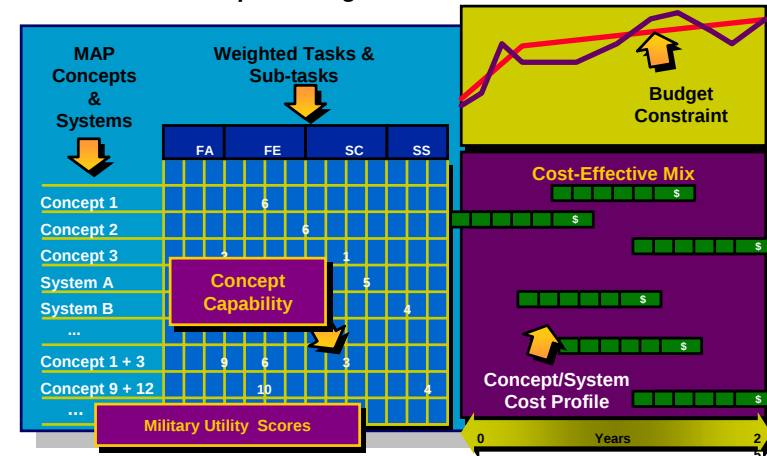
- **ASIIS**
- **QATO**
- **HAT**
- **Lightning**



ASIIS Description

AeroSpace Integrated Investment Software

- Budget constrained cost and utility optimizer
- Inputs:
 - System level engineering inputs
 - Cost information
 - Launch information (for space-based concepts)
 - Relationship and synergy information
 - Budget information
- Output is optimal set of systems based on Goal programming, Maximum Modeling Approach, and Mixed-Integer Linear Programming
- Optimal solution sets are input into QATO, HAT and LIGHTNING to compare system value against competing concepts and to determine military utility.





- | Budget | | Browsers | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
|---------|-----------|------------------------------------|------------|----------|----------|----------|----------|----------|----------|------------|----------|----------|------------|-----------|------------|-----------|----------|------------|------------|----------|------------|------------|------------|------------|------------|------------|------------|------------|------------|----------|
| | | Click to Main Menu | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Budget: | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| D | Budget | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 31 | Bob's | Cost | Total (\$) | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 | 2024 | 2025 | 2026 | 2027 | 2028 | 2029 | 2030 | | |
| | | Overhead | 1980.00 | 207.200 | 298.200 | 404.256 | 434.625 | 688.652 | 763.266 | 728.678 | 765.522 | 828.564 | 891.653 | 821.795 | 784.129 | 877.999 | 994.741 | 899.074 | 872.821 | 898.805 | 726.190 | 715.000 | 715.000 | 715.000 | 715.000 | 715.000 | 715.000 | 715.000 | 715.000 | |
| | | CBA | 4387.938 | 182.074 | 193.687 | 154.138 | 199.432 | 121.096 | 138.477 | 158.951 | 167.537 | 186.820 | 171.495 | 175.262 | 182.025 | 243.833 | 90.288 | 76.018 | 56.109 | 60.956 | 19.898 | 19.898 | 19.898 | 19.898 | 19.898 | 19.898 | 19.898 | 19.898 | 19.898 | |
| | | Overhead | -15,322.22 | -55.16 | -181.522 | -236.505 | -405.403 | -576.505 | -624.319 | -620.127 | -627.805 | -703.344 | -734.500 | -638.473 | -632.098 | -633.256 | -896.453 | -924.056 | -986.722 | -745.619 | -637.727 | -637.727 | -637.727 | -637.727 | -637.727 | -637.727 | -637.727 | -637.727 | -637.727 | |
| 32 | Bill's | Cost | 19520.99 | 255.796 | 545.432 | 701.897 | 486.624 | 350.328 | 274.839 | 362.795 | 497.229 | 604.325 | 749.261 | 782.620 | 681.348 | 769.676 | 839.857 | 872.838 | 861.807 | 766.798 | 1852.190 | 1852.190 | 1852.190 | 1852.190 | 1852.190 | 1852.190 | 1852.190 | 1852.190 | 1852.190 | |
| | | CBA | 20070 | 68.893 | 65.853 | 63.873 | 61.128 | 60.823 | 57.843 | 284.247 | 437.271 | 922.678 | 1289.610 | 1338.623 | 1395.630 | 1270.652 | 1299.860 | 1439.796 | 1505.057 | 1457.545 | 1810.190 | 1810.190 | 1810.190 | 1810.190 | 1810.190 | 1810.190 | 1810.190 | 1810.190 | 1810.190 | |
| | | Overhead | -1,645.94 | -103.093 | -419.976 | -410.824 | -454.639 | -320.495 | -100.508 | -1,034.272 | -535.829 | -788.995 | -1,109.346 | -1088.003 | -1,247.292 | -1091.914 | -947.923 | -1,068.956 | -1,035.259 | -955.259 | -1,035.259 | -1,035.259 | -1,035.259 | -1,035.259 | -1,035.259 | -1,035.259 | -1,035.259 | -1,035.259 | -1,035.259 | |
| 33 | Jim's | Cost | 0 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | |
| | | CBA | 1706 | 123.000 | 246.000 | 234.000 | 243.000 | 189.000 | 87.200 | 272.000 | 322.000 | 342.000 | 342.000 | 342.000 | 342.000 | 342.000 | 342.000 | 342.000 | 342.000 | 342.000 | 342.000 | 342.000 | 342.000 | 342.000 | 342.000 | 342.000 | 342.000 | 342.000 | 342.000 | 342.000 |
| | | Overhead | -1706 | -123.000 | -246.000 | -234.000 | -243.000 | -189.000 | -87.200 | -272.000 | -322.000 | -342.000 | -342.000 | -342.000 | -342.000 | -342.000 | -342.000 | -342.000 | -342.000 | -342.000 | -342.000 | -342.000 | -342.000 | -342.000 | -342.000 | -342.000 | -342.000 | -342.000 | -342.000 | -342.000 |
| | Arch Cost | | 29212.12 | 462.396 | 893.641 | 1182.193 | 939.1459 | 830.0235 | 1003.235 | 1141.473 | 1282.795 | 1430.489 | 1601.224 | 1696.395 | 1465.477 | 1666.798 | 1834.398 | 1771.912 | 1734.638 | 1673.483 | 1868.910 | 1868.910 | 1868.910 | 1868.910 | 1868.910 | 1868.910 | 1868.910 | 1868.910 | 1868.910 | 1868.910 |
| | Total CBA | | 36143.92 | 340.367 | 451.240 | 442.011 | 493.957 | 351.625 | 479.230 | 692.798 | 936.808 | 1039.498 | 1237.056 | 1513.885 | 1467.665 | 1694.485 | 1388.263 | 1594.814 | 1671.965 | 1618.131 | 2005.000 | 2005.000 | | | | | | | | |



HAT Description

Applications

Reconnaissance: Developed a process & a recommended mix of airborne ISR capabilities
Source Selection Evaluation

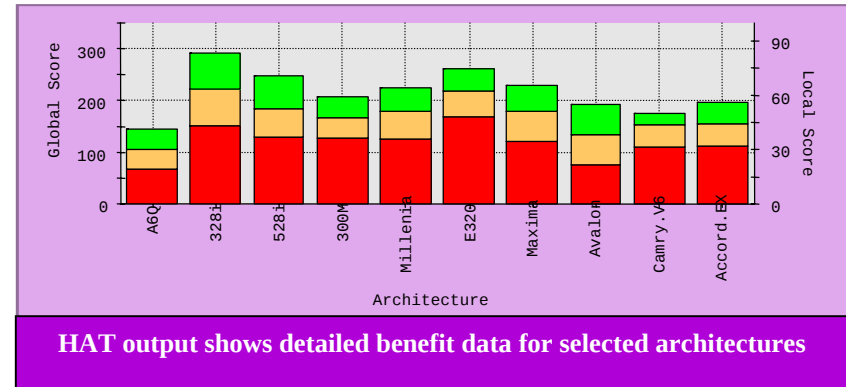
- Selected best value combination of EO, SAR, & IR capabilities for \$10B acquisition
- Identified “best” surface ship design & compelling rationale

Budget Allocation: Recommend a set of Programs

& Initiatives responsive to diverse user needs within fiscal constraints

Analysis of Alternatives (AoAs)

- Space Control
- Space Situational Awareness
- Operationally Responsive Spacelift (ORS)
- Future space architectures & initiatives



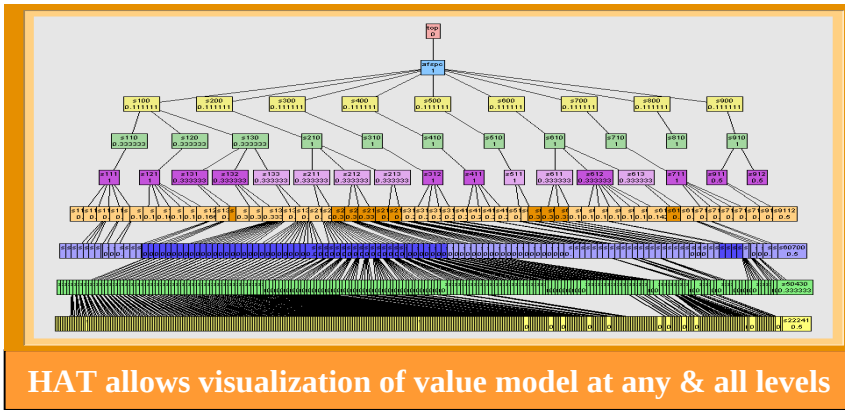
Capabilities

Fast

- Runs in minutes on a standard PC
- Data input changes can be made within hours

Flexible

- Tailored to customer needs
- Evaluate leadership “what-ifs”



Runtime Environment

Required: Windows 2000/NT/98

Recommended: 500Mhz P3, 256MB Ram, 10+GB HD





Lightning Description

Capabilities

Fast

- 30-day campaign runs in a minute on a PC
- Run thousands of variations in a few days

Flexible

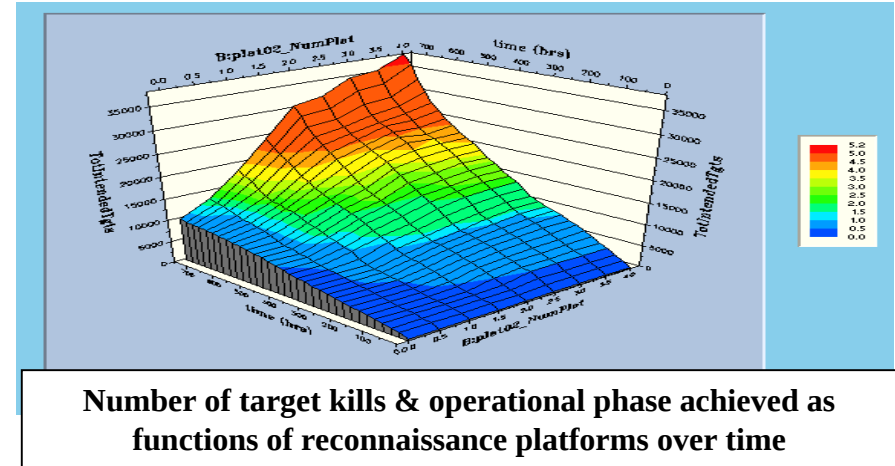
- 30000+ potential experimental variables

Perception Model

- Truth & perceived states modeled via Battle-Space Awareness Matrix
- Known and unknown target identity
- Known and unknown target locations

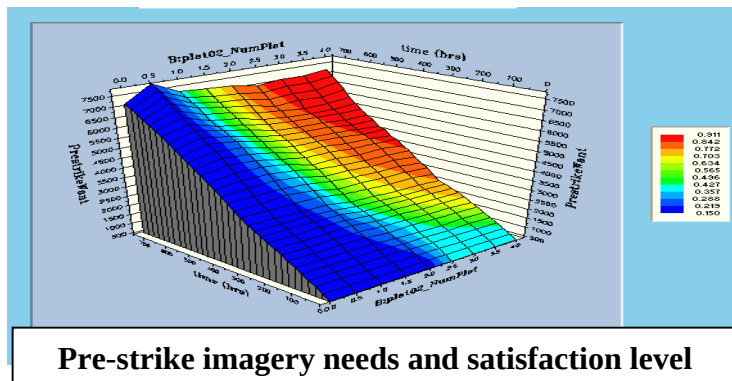
Processes

- Air-to-Ground attacks
- Air-to-Air and Surface-to-Air attrition
- Reconnaissance & Surveillance
- Movement & Repair
- Linear program used to simulate daily ATOs based on perceived battle space state



Applications

- Military utility of architectures and ops concepts
- Operational Impact of space system capabilities & Force-on-Force Studies
- Quick turnaround analyses using parametric sensitivity
- High dimensional full-factorial preview experiments to guide expensive high-fidelity model runs
- “What if” Experiments to determine sensitivity of battle outcomes to operational factors





Model Integration Process

- Orbit/Basing data and concept feasibility from MAA, MNA and MSA analyses are fed into the GUARDIAN engagement analysis model
- Engagement probability is returned from Guardian for input into ASIIS and Lightning
- Additional MAA, MNA and MSA outputs are entered into ASIIS
 - Cost Profile
 - IOC/FOC
 - Task Service Coverage
 - Identification
 - Launch Costs
 - Precedence
 - Weighting
 - Infrastructure
 - Utility score
- ASIIS generates candidate architectures (family-of-systems)



Model Integration Process (Continued)

- **ASIIS-generated architectures are entered into QATO**
- **QATO provides the ability to modify a given roadmap**
 - **By turning systems on or off**
 - **Changing start/IOC/FOC/stop dates**
 - **By changing the budget authority**
- **QATO returns:**
 - **The different budgets, roadmap costs and an over/under budget comparison for each budget and total budget**
 - **Effectiveness score for the architecture, listed by task and each system that contributes to that task effectiveness along with a summed task effectiveness task row for that task**



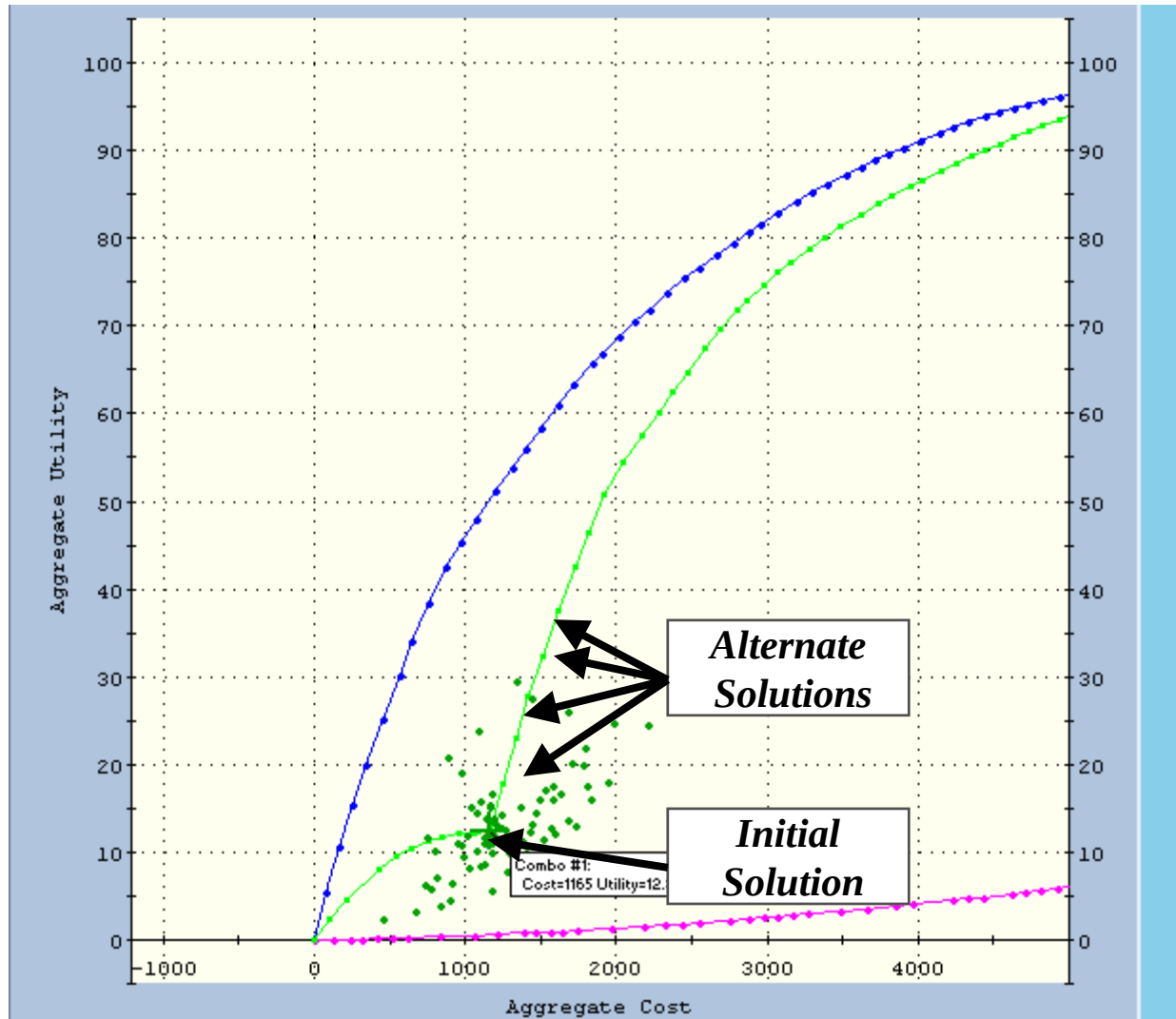
Model Integration Process (Continued)

- **ASIS-generated architectures are also entered into HAT**
- **HAT calculates “Bang-for-Buck” utility and generates a Pareto space to assess cost/benefit of each candidate architecture**
 - **Analysis of the Pareto space allows the analyst to recommend addition/removal of systems in the architecture to improve cost/benefit**
- **The refined architecture from the HAT model is returned to QATO to ensure the architecture meets budget/performance constraints**



Model Integration Process (Continued)

Pareto Space Analysis



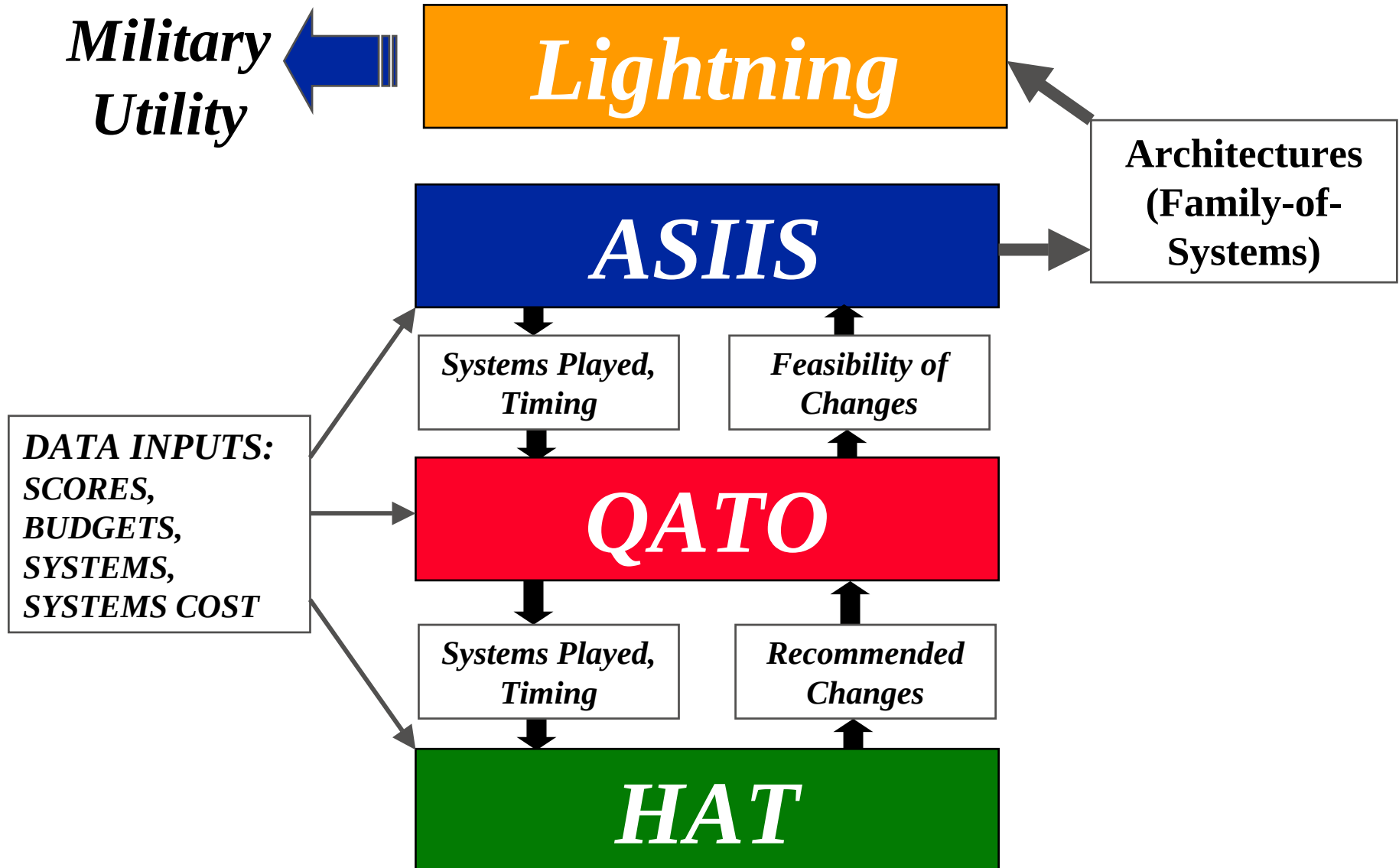


Model Integration Process (Continued)

- **This QATO/HAT process is iterated until cost/benefit is maximized and the architecture meets fiscal constraints**
- **The revised architecture is then returned to ASIIS to ensure the architecture meets feasibility constraints**
- **This ASIIS/QATO/HAT cycle continues until an “optimal” solution is reached**
- **The finalized architecture is evaluated in the Lightning campaign model to provide a military utility analysis (MUA) assessment**



How the Tools Interact





Conclusion

- **Development of QATO**
- **Standardization/Integration of analytical models**
- **Process developed in pathfinder provided additional analytical rigor to traditional IPP**
- **Pathfinder analytical process resulted in more robust architectures**
- **New process provided additional sensitivity analysis**
- ***Military utility explicitly measured***



QUESTIONS?

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