

REPORT DOCUMENTATION PAGE				Form Approved OMB No. 0704-0188	
Public reporting burden for this collection of information is estimated to average 1 hour per response, including the time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing this collection of information. Send comments regarding this burden estimate or any other aspect of this collection of information, including suggestions for reducing this burden to Department of Defense, Washington Headquarters Services, Directorate for Information Operations and Reports (0704-0188), 1215 Jefferson Davis Highway, Suite 1204, Arlington, VA 22202-4302. Respondents should be aware that notwithstanding any other provision of law, no person shall be subject to any penalty for failing to comply with a collection of information if it does not display a currently valid OMB control number. PLEASE DO NOT RETURN YOUR FORM TO THE ABOVE ADDRESS.					
1. REPORT DATE (DD-MM-YYYY) 22-07-2011		2. REPORT TYPE Briefing Slides		3. DATES COVERED (From - To)	
4. TITLE AND SUBTITLE An Integrated Approach to Systems Engineering through Modeling and Simulation				5a. CONTRACT NUMBER FA9300-10-C-4002	
				5b. GRANT NUMBER	
				5c. PROGRAM ELEMENT NUMBER	
6. AUTHOR(S) Michael O'Such				5d. PROJECT NUMBER	
				5f. WORK UNIT NUMBER 484710HZ	
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) Advatech Pacific 560 E Hospitality Lane, Ste 400 San Bernardino CA 92408-3545				8. PERFORMING ORGANIZATION REPORT NUMBER AFRL-RZ-ED-VG-2011-323	
9. SPONSORING / MONITORING AGENCY NAME(S) AND ADDRESS(ES) Air Force Research Laboratory (AFMC) AFRL/RZS 5 Pollux Drive Edwards AFB CA 93524-7048				10. SPONSOR/MONITOR'S ACRONYM(S)	
				11. SPONSOR/MONITOR'S NUMBER(S) AFRL-RZ-ED-VG-2011-323	
12. DISTRIBUTION / AVAILABILITY STATEMENT Approved for public release; distribution unlimited (PA #11553).					
13. SUPPLEMENTARY NOTES For presentation at the AIAA Modeling and Simulation Conference, Portland, OR, 8-11 August 2011.					
14. ABSTRACT Modeling and simulation is a key enabler for the systems engineering process and can support the affordability goals for new programs by performing trade studies during the pre-acquisition phase of new programs. Modeling and simulation allows program managers and designers to assess the impact of system requirements and the introduction of new technologies early in the design phase and to assess alternative concepts, identifying the best approach to fulfill the requirements before significant funding has been expended. Advatech Pacific, Inc. (Advatech), is under the direction of the Air Force Research Laboratory (AFRL), and with their support is currently developing the Integrated System and Cost Modeling (ISCM) tool suite that addresses the impact of system requirements and technology insertion and explores trade spaces throughout the life cycle of a program.					
15. SUBJECT TERMS					
16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON Tiffany Rexius
a. REPORT Unclassified	b. ABSTRACT Unclassified	c. THIS PAGE Unclassified			19b. TELEPHONE NUMBER (include area code) N/A



Advatech Pacific

Changing The Way Engineering Is Conducted™



An Integrated Approach to Systems Engineering through Modeling and Simulation

Presenter:

Michael O'Such

This material is based upon work supported by
AFRL/RVES and AFRL/RZST under AFRL/RVES Contract No.
FA9453-05-D-0002 and AFRL/RZST Contract No. FA9300-10-C-
4002

Distribution A: Approved for Public Release (PA# Pending)



Advatech Pacific, Inc. Background



An Aerospace Engineering Research & Development Company Founded in 1995 primarily focused on:

- Aerospace Vehicle Physics-based Modeling, Simulation and Analysis
- Electronic Communications System Interoperability
- Aerospace Engineering Design and Analysis Services



Past M&S Efforts

- IPAT (Effort Began: 2002)

- Expansion of Reusable Military Launch System (RMLS) developed at WPAFB
- Developed for rapid assessment of launch vehicle designs for AFRL/RZST
- Integration of industry standard tools (CEA, POST, MINIVER, DATCOM)
- Various propulsion types and vehicle types modeled

- ACES-ISET (Effort Began: 2003)

- Developed to fulfill the need for an overall space mission trade study tool for AFRL/RV
- Integrates the Space Mission and Analysis Design worksheet for spacecraft assessment and additional mass-estimating relationships for small satellites
- Models spacecraft radiation environment
- Unmanned Space Vehicle Cost Model, Small Satellite Cost Model, NASA Instrument Cost Model used to estimate spacecraft costs
- Integrates launch vehicles from a database of existing launch vehicle or can import a launch vehicle model from IPAT

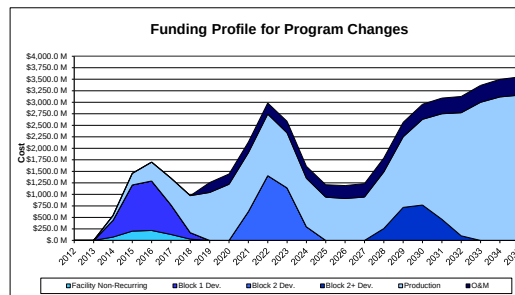
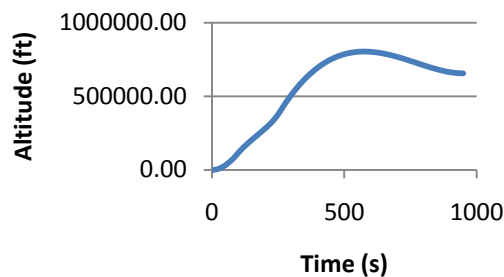
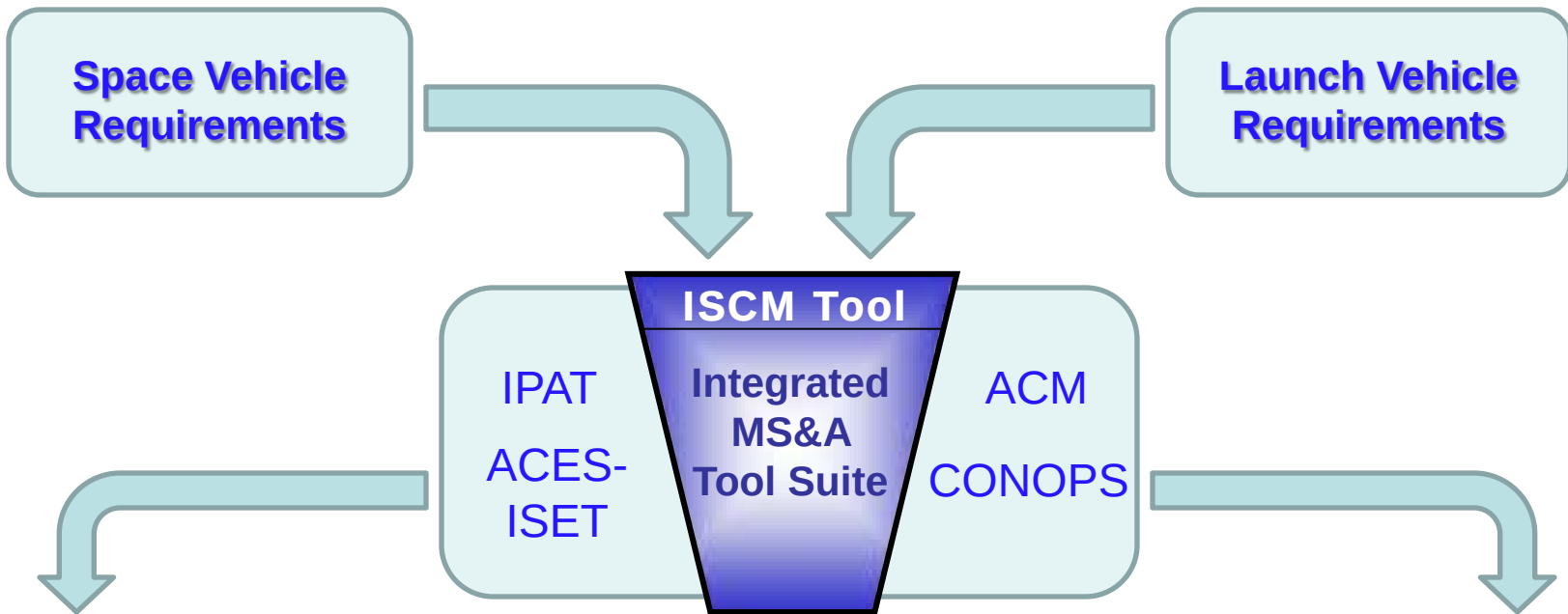


Past M&S Efforts

- ACM (Effort Began: 2006)
 - Uses CERs and acquisition strategies to estimate development, procurement and top-level launch costs for expendable and solid launch vehicles
 - CERs developed by Dr. Roy Smoker of MCR using historical program data, statistical analysis, and NASA and DoD TRLs
 - Incorporates risk assessment
 - Integrated with IPAT
- CONOPS (Effort Began: 2009)
 - Analysis of faculties and labor cost
 - Launch availability and reliability estimates
 - Generates baseline launch operations schedule
 - Integrated with IPAT and ACES-ISET



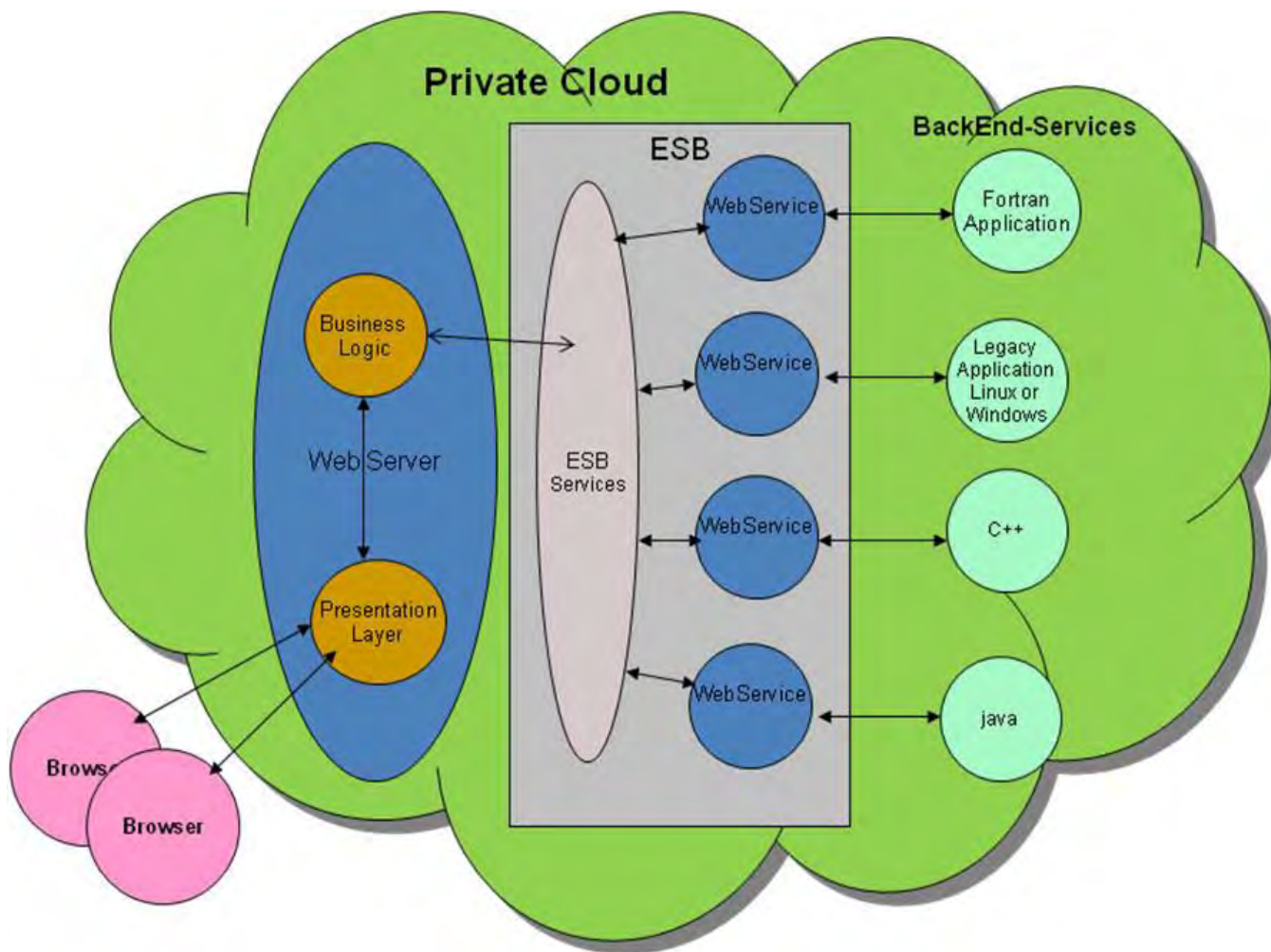
ISCM Integration Concept



Task ID	Phase	Work Description/Structure Element	Duration
1	1	Site - 4 Stage Joint Horizontal Pod	23.67 days
2	1.1	Proforma and Assemblies Missile Stages	9.27 days
3	1.1.1	Proforma Missile Stages	4.8 days
4	1.1.2	Integrated Buildup of Missile on Transporter	4.57 days
5	1.2	Transport to Integration	8.6 days
6	1.3	Proforma and Encasement Satellite	7.6 days
7	1.4	Transport Stages to Program	3.6 days
8	1.5	System Int	4.8 days
9	1.6	System Int	4.8 days
10	1.7	Ground Ops	4.8 days
11	1.8	Ground Ops	4.8 days
12	1.9	Ground Ops	4.8 days
13	1.10	Ground Ops	4.8 days
14	1.11	Ground Ops	4.8 days
15	1.12	Ground Ops	4.8 days
16	1.13	Ground Ops	4.8 days
17	1.14	Ground Ops	4.8 days
18	1.15	Ground Ops	4.8 days
19	1.16	Ground Ops	4.8 days
20	1.17	Ground Ops	4.8 days
21	1.18	Ground Ops	4.8 days
22	1.19	Ground Ops	4.8 days
23	1.20	Ground Ops	4.8 days
24	1.21	Ground Ops	4.8 days
25	1.22	Ground Ops	4.8 days
26	1.23	Ground Ops	4.8 days
27	1.24	Ground Ops	4.8 days
28	1.25	Ground Ops	4.8 days
29	1.26	Ground Ops	4.8 days
30	1.27	Ground Ops	4.8 days
31	1.28	Ground Ops	4.8 days
32	1.29	Ground Ops	4.8 days
33	1.30	Ground Ops	4.8 days
34	1.31	Ground Ops	4.8 days
35	1.32	Ground Ops	4.8 days
36	1.33	Ground Ops	4.8 days
37	1.34	Ground Ops	4.8 days
38	1.35	Ground Ops	4.8 days
39	1.36	Ground Ops	4.8 days
40	1.37	Ground Ops	4.8 days
41	1.38	Ground Ops	4.8 days
42	1.39	Ground Ops	4.8 days
43	1.40	Ground Ops	4.8 days
44	1.41	Ground Ops	4.8 days
45	1.42	Ground Ops	4.8 days
46	1.43	Ground Ops	4.8 days
47	1.44	Ground Ops	4.8 days
48	1.45	Ground Ops	4.8 days
49	1.46	Ground Ops	4.8 days
50	1.47	Ground Ops	4.8 days
51	1.48	Ground Ops	4.8 days
52	1.49	Ground Ops	4.8 days
53	1.50	Ground Ops	4.8 days
54	1.51	Ground Ops	4.8 days
55	1.52	Ground Ops	4.8 days
56	1.53	Ground Ops	4.8 days
57	1.54	Ground Ops	4.8 days
58	1.55	Ground Ops	4.8 days
59	1.56	Ground Ops	4.8 days
60	1.57	Ground Ops	4.8 days
61	1.58	Ground Ops	4.8 days
62	1.59	Ground Ops	4.8 days
63	1.60	Ground Ops	4.8 days
64	1.61	Ground Ops	4.8 days
65	1.62	Ground Ops	4.8 days
66	1.63	Ground Ops	4.8 days
67	1.64	Ground Ops	4.8 days
68	1.65	Ground Ops	4.8 days
69	1.66	Ground Ops	4.8 days
70	1.67	Ground Ops	4.8 days
71	1.68	Ground Ops	4.8 days
72	1.69	Ground Ops	4.8 days
73	1.70	Ground Ops	4.8 days
74	1.71	Ground Ops	4.8 days
75	1.72	Ground Ops	4.8 days
76	1.73	Ground Ops	4.8 days
77	1.74	Ground Ops	4.8 days
78	1.75	Ground Ops	4.8 days
79	1.76	Ground Ops	4.8 days
80	1.77	Ground Ops	4.8 days
81	1.78	Ground Ops	4.8 days
82	1.79	Ground Ops	4.8 days
83	1.80	Ground Ops	4.8 days
84	1.81	Ground Ops	4.8 days
85	1.82	Ground Ops	4.8 days
86	1.83	Ground Ops	4.8 days
87	1.84	Ground Ops	4.8 days
88	1.85	Ground Ops	4.8 days
89	1.86	Ground Ops	4.8 days
90	1.87	Ground Ops	4.8 days
91	1.88	Ground Ops	4.8 days
92	1.89	Ground Ops	4.8 days
93	1.90	Ground Ops	4.8 days
94	1.91	Ground Ops	4.8 days
95	1.92	Ground Ops	4.8 days
96	1.93	Ground Ops	4.8 days
97	1.94	Ground Ops	4.8 days
98	1.95	Ground Ops	4.8 days
99	1.96	Ground Ops	4.8 days
100	1.97	Ground Ops	4.8 days
101	1.98	Ground Ops	4.8 days
102	1.99	Ground Ops	4.8 days
103	2.00	Ground Ops	4.8 days
104	2.01	Ground Ops	4.8 days
105	2.02	Ground Ops	4.8 days
106	2.03	Ground Ops	4.8 days
107	2.04	Ground Ops	4.8 days
108	2.05	Ground Ops	4.8 days
109	2.06	Ground Ops	4.8 days
110	2.07	Ground Ops	4.8 days
111	2.08	Ground Ops	4.8 days
112	2.09	Ground Ops	4.8 days
113	2.10	Ground Ops	4.8 days
114	2.11	Ground Ops	4.8 days
115	2.12	Ground Ops	4.8 days
116	2.13	Ground Ops	4.8 days
117	2.14	Ground Ops	4.8 days
118	2.15	Ground Ops	4.8 days
119	2.16	Ground Ops	4.8 days
120	2.17	Ground Ops	4.8 days
121	2.18	Ground Ops	4.8 days
122	2.19	Ground Ops	4.8 days
123	2.20	Ground Ops	4.8 days
124	2.21	Ground Ops	4.8 days
125	2.22	Ground Ops	4.8 days
126	2.23	Ground Ops	4.8 days
127	2.24	Ground Ops	4.8 days
128	2.25	Ground Ops	4.8 days
129	2.26	Ground Ops	4.8 days
130	2.27	Ground Ops	4.8 days
131	2.28	Ground Ops	4.8 days
132	2.29	Ground Ops	4.8 days
133	2.30	Ground Ops	4.8 days
134	2.31	Ground Ops	4.8 days
135	2.32	Ground Ops	4.8 days
136	2.33	Ground Ops	4.8 days
137	2.34	Ground Ops	4.8 days
138	2.35	Ground Ops	4.8 days
139	2.36	Ground Ops	4.8 days
140	2.37	Ground Ops	4.8 days
141	2.38	Ground Ops	4.8 days
142	2.39	Ground Ops	4.8 days
143	2.40	Ground Ops	4.8 days
144	2.41	Ground Ops	4.8 days
145	2.42	Ground Ops	4.8 days
146	2.43	Ground Ops	4.8 days
147	2.44	Ground Ops	4.8 days
148	2.45	Ground Ops	4.8 days
149	2.46	Ground Ops	4.8 days
150	2.47	Ground Ops	4.8 days
151	2.48	Ground Ops	4.8 days
152	2.49	Ground Ops	4.8 days
153	2.50	Ground Ops	4.8 days
154	2.51	Ground Ops	4.8 days
155	2.52	Ground Ops	4.8 days
156	2.53	Ground Ops	4.8 days
157	2.54	Ground Ops	4.8 days
158	2.55	Ground Ops	4.8 days
159	2.56	Ground Ops	4.8 days
160	2.57	Ground Ops	4.8 days
161	2.58	Ground Ops	4.8 days
162	2.59	Ground Ops	4.8 days
163	2.60	Ground Ops	4.8 days
164	2.61	Ground Ops	4.8 days
165	2.62	Ground Ops	4.8 days
166	2.63	Ground Ops	4.8 days
167	2.64	Ground Ops	4.8 days
168	2.65	Ground Ops	4.8 days
169	2.66	Ground Ops	4.8 days
170	2.67	Ground Ops	4.8 days
171	2.68	Ground Ops	4.8 days
172	2.69	Ground Ops	4.8 days
173	2.70	Ground Ops	4.8 days
174	2.71	Ground Ops	4.8 days
175	2.72	Ground Ops	4.8 days
176	2.73	Ground Ops	4.8 days
177	2.74	Ground Ops	4.8 days
178	2.75	Ground Ops	4.8 days
179	2.76	Ground Ops	4.8 days
180	2.77	Ground Ops	4.8 days
181	2.78	Ground Ops	4.8 days
182	2.79	Ground Ops	4.8 days
183	2.80	Ground Ops	4.8 days
184	2.81	Ground Ops	4.8 days
185	2.82	Ground Ops	4.8 days
186	2.83	Ground Ops	4.8 days
187	2.84	Ground Ops	4.8 days
188	2.85	Ground Ops	4.8 days
189	2.86	Ground Ops	4.8 days
190	2.87	Ground Ops	4.8 days
191	2.88	Ground Ops	4.8 days
192	2.89	Ground Ops	4.8 days
193	2.90	Ground Ops	4.8 days
194	2.91	Ground Ops	4.8 days
195	2.92	Ground Ops	4.8 days
196	2.93	Ground Ops	4.8 days
197	2.94	Ground Ops	4.8 days
198	2.95	Ground Ops	4.8 days
199	2.96	Ground Ops	4.8 days
200	2.97	Ground Ops	4.8 days
201	2.98	Ground Ops	4.8 days
202	2.99	Ground Ops	4.8 days
203	3.00	Ground Ops	4.8 days
204	3.01	Ground Ops	4.8 days
205	3.02	Ground Ops	4.8 days
206	3.03	Ground Ops	4.8 days
207	3.04	Ground Ops	4.8 days
208	3.05	Ground Ops	4.8 days
209	3.06	Ground Ops	4.8 days
210	3.07	Ground Ops	4.8 days
211	3.08	Ground Ops	4.8 days
212	3.09	Ground Ops	4.8 days
213	3.10	Ground Ops	4.8 days
214	3.11	Ground Ops	4.8 days
215	3.12	Ground Ops	4.8 days
216	3.13	Ground Ops	4.8 days
217	3.14	Ground Ops	4.8 days
218	3.15	Ground Ops	4.8 days
219	3.16	Ground Ops	4.8 days
220	3.17	Ground Ops	4.8 days
221	3.18	Ground Ops	4.8 days
222	3.19	Ground Ops	4.8 days
223	3.20	Ground Ops	4.8 days
224	3.21	Ground Ops	4.8 days
225	3.22	Ground Ops	4.8 days
226	3.23	Ground Ops	4.8 days
227	3.24	Ground Ops	4.8 days
228	3.25	Ground Ops	4.8 days
229	3.26	Ground Ops	4.8 days
230	3.27	Ground Ops	4.8 days
231	3.28	Ground Ops	4.8 days
232	3.29	Ground Ops	4.8 days
233	3.30	Ground Ops	4.8 days
234	3.31	Ground Ops	4.8 days
235	3.32	Ground Ops	4.8 days
236	3.33	Ground Ops	4.8 days
237	3.34	Ground Ops	4.8 days
238	3.35	Ground Ops	4.8 days
239	3.36	Ground Ops	4.8 days
240	3.37	Ground Ops	4.8 days
241	3.38	Ground Ops	4.8 days
242	3.39	Ground Ops	4.8 days
243	3.40	Ground Ops	4.8 days
244	3.41	Ground Ops	4.8 days
245	3.42	Ground Ops	4.8 days
246	3.43	Ground Ops	4.8 days
247	3.44	Ground Ops	4.8 days
248	3.45	Ground Ops	4.8 days
249	3.46	Ground Ops	4.8 days
250	3.47	Ground Ops	4.8 days
251	3.48	Ground Ops	4.8 days
252	3.49	Ground Ops	4.8 days
253	3.50	Ground Ops	4.8 days
254	3.51	Ground Ops	4.8 days
255	3.52	Ground Ops	4.8 days
256	3.53	Ground Ops	4.8 days
257	3.54	Ground Ops	4.8 days
258	3.55	Ground Ops	4.8 days
259	3.56	Ground Ops	4.8 days
260	3.57	Ground Ops	4.8 days
261	3.58	Ground Ops	4.8 days
262	3.59	Ground Ops	4.8 days
263	3.60	Ground Ops	4.8 days
264	3.61	Ground Ops	4.8 days
265	3.62	Ground Ops	4.8 days
266	3.63	Ground Ops	4.8 days
267	3.64	Ground Ops	4.8 days
268	3.65	Ground Ops	4.8 days
269	3.66	Ground Ops	4.8 days
270	3.67	Ground Ops	4.8 days
271	3.68	Ground Ops	4.8 days
272	3.69	Ground Ops	4.8 days
273	3.70	Ground Ops	4.8 days
274	3.71	Ground Ops	4.8 days
275	3.72	Ground Ops	4.8 days
276	3.73	Ground Ops	4.8 days
277	3.74	Ground Ops	4.8 days
278	3.75	Ground Ops	4.8 days
279	3.76	Ground Ops	4.8 days
280	3.77	Ground Ops	4.8 days
281	3.78	Ground Ops	4.8 days
282	3.79	Ground Ops	4.8 days
283	3.80	Ground Ops	4.8 days
284	3.81	Ground Ops	4.8 days
285	3.82	Ground Ops	4.8 days
286	3.83	Ground Ops	4.8 days
287	3.84	Ground Ops	4.8 days
288	3.85	Ground Ops	4.8 days
289	3.86	Ground Ops	4.8 days
290	3.87	Ground Ops	4.8 days
291	3.88	Ground Ops	4.8 days
292	3.89	Ground Ops	4.8 days
293	3.90	Ground Ops	4.8 days
294	3.91	Ground Ops	4.8 days
295	3.92	Ground Ops	4.8 days
296	3.93	Ground Ops	4.8 days
297	3.94	Ground Ops	4.8 days
298	3.95	Ground Ops	4.8 days
299	3.96	Ground Ops	4.8 days
300	3.97	Ground Ops	4.8 days
301	3.98	Ground Ops	4.8 days
302	3.99	Ground Ops	4.8 days
303	4.00	Ground Ops	4.8 days
304	4.01	Ground Ops	4.8 days
305	4.02	Ground Ops	4.8 days
306	4.03	Ground Ops	4.8 days
307	4.04	Ground Ops	4.8 days
308	4.05	Ground Ops	4.8 days
309	4.06	Ground Ops	4.8 days
310	4.07	Ground Ops	4.8 days
311	4.08	Ground Ops	4.8 days
312	4.09	Ground Ops	4.8 days
313	4.10	Ground Ops	4.8 days
314	4.11	Ground Ops	4.8 days
315	4.12	Ground Ops	4.8 days
316	4.13	Ground Ops	4.8 days
317	4.14	Ground Ops	4.8 days
318	4.15	Ground Ops	4.8 days



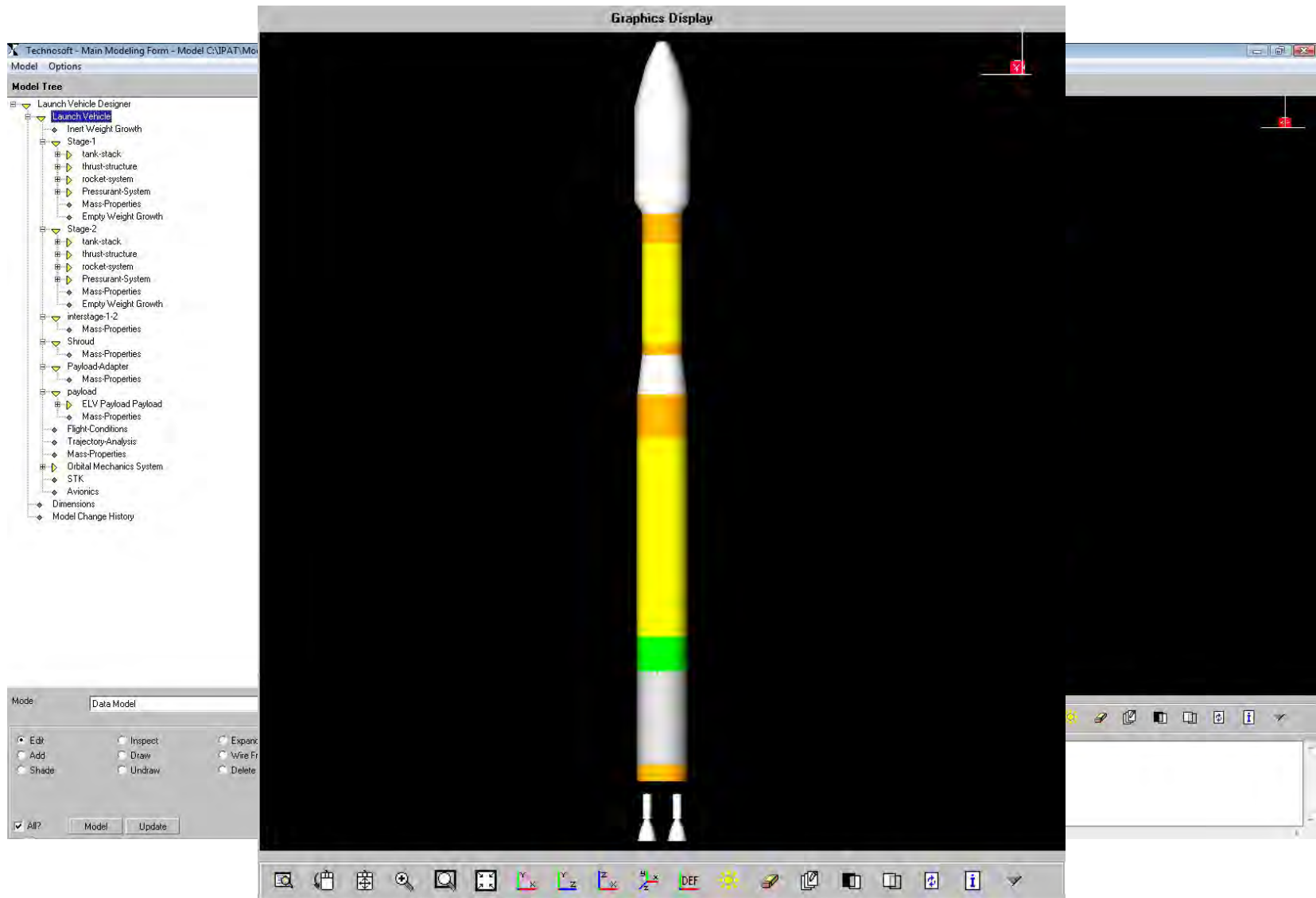
ISCM Service-Oriented Architecture



Distribution A: Approved for Public
release (PA#)



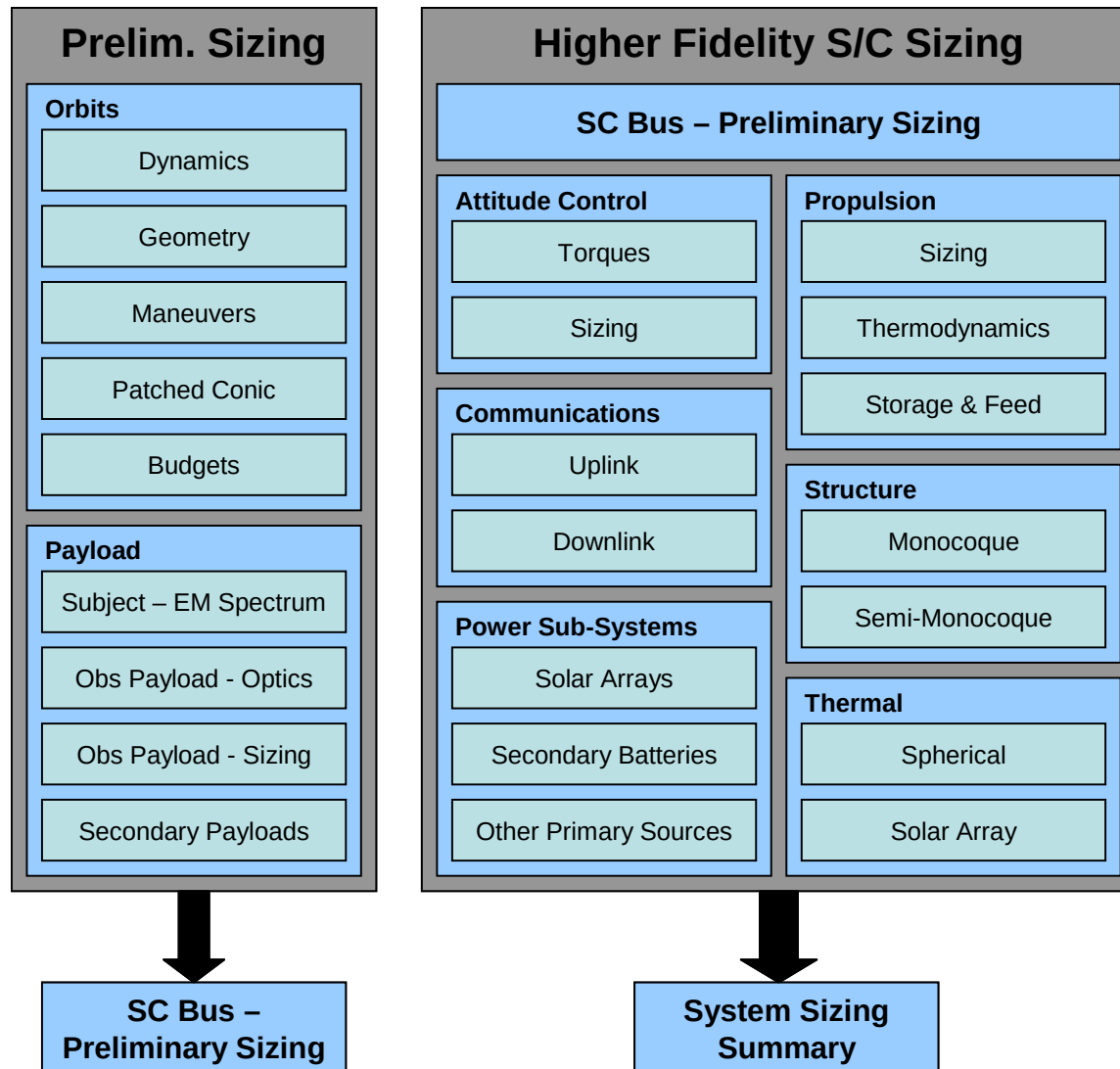
Launch Vehicle Performance



Distribution A: Approved for Public release (PA#)



Space Vehicles



Distribution A: Approved for Public release (PA#)



Launch Vehicle Cost Analysis



- Parametric Estimation: $AUC_i = \alpha_i W_i^{\beta_i}$
- Historical data derives cost-estimating relationships (α and β values)
- CERs tied to TRLs and project milestones (PDR, CDR, etc)
- Complete life-cycle costs with risk analysis (FRISK) incorporated



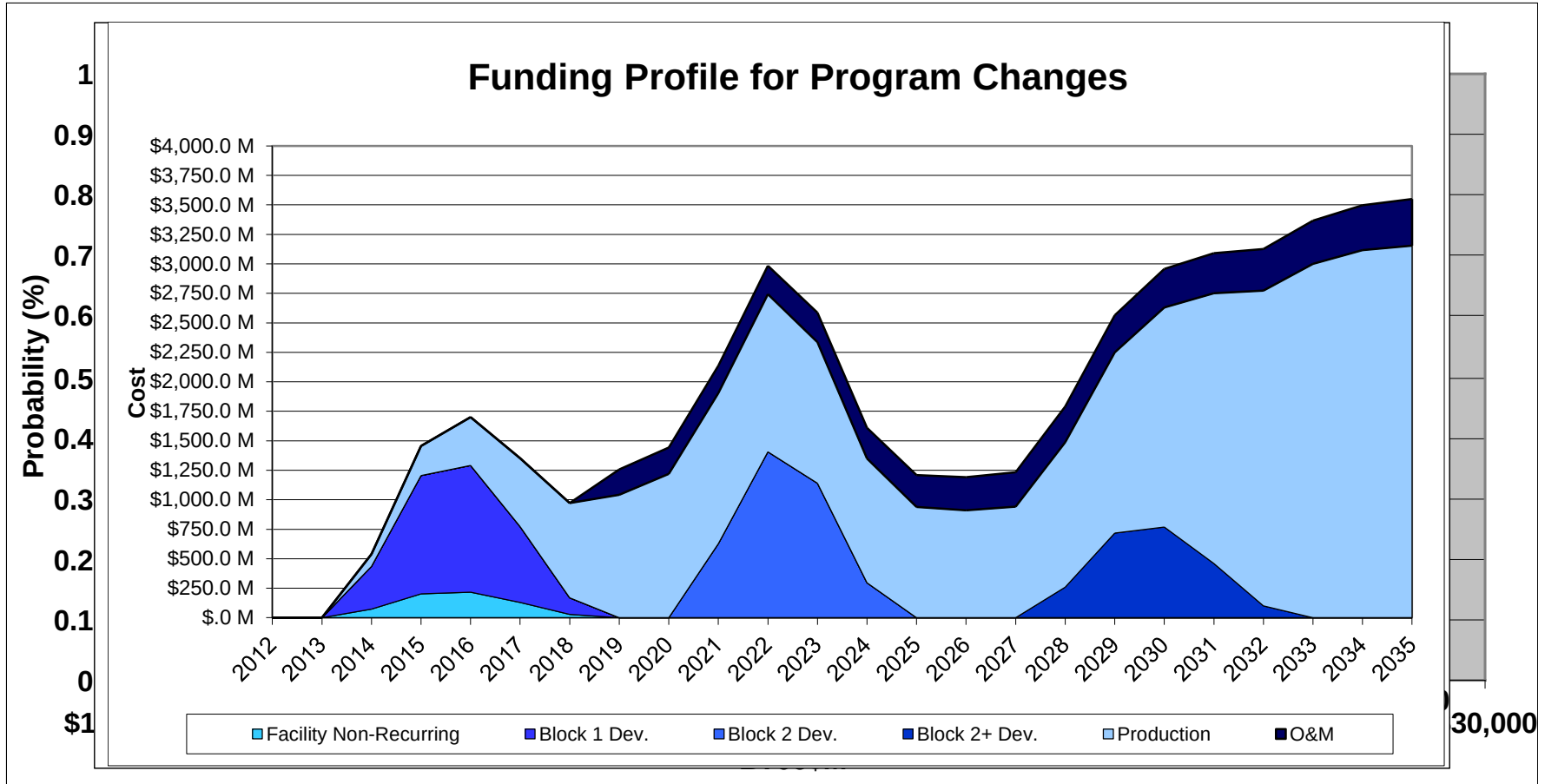
Launch Vehicle Cost Analysis



TRL	NASA	Defense Acquisition Management Framework
1	Basic principles observed and reported	Paper studies of alternative concepts for meeting a mission
2	Technology concept and/or application formulated	Analysis of alternatives; Validated and approved needs Statement (MNS); Exit criteria: Having specific concept to be pursued and technology exists
3	Analytical and experimental critical function and/or characteristic proof of concept	Concept in hand, but system architecture to be developed; Exit criteria: Development Contract Awarded
4	Component and/or breadboard validation in laboratory environment	Architecture complete, but components need to be integrated into complete system; Exit criteria: Preliminary Design Review (PDR)
5	Component and/or breadboard validation in relevant environment	System prototypes demonstrated in relevant environment; Exit criteria: Critical Design Review (CDR)
6	System/subsystem model or prototype demonstration in a relevant environment	System demonstrated in its intended environment; Exit criteria: System Verification Review (SVR)
7	System prototype demonstration in a space (if applicable) environment	Technically Mature; Low Rate Initial Production; Exit Criteria: Initial Operational Capability (IOC)
8	Actual system demonstration and "flight qualified"	Initial Operational Capability; System operationally effective; Exit Criteria: Manufacturing ready for full-rate production
9	Actual system "flight-proven" through successful mission operation	Full-rate production; Deploy System; Exit Criteria: Full Operational Capability



Launch Vehicle Cost Analysis



Distribution A: Approved for Public
release (PA#)



Space Vehicle Cost Analysis

- Excel-based model includes several validated cost models
 - Unmanned Space Vehicle Cost Model (USCM)
 - Small Satellite Cost Model (SSCM)
 - NASA Instrument Cost Model (NICM)
 - Constructive Cost Model II (COCOMO II)
- Air Force Cost Analysis Agency (AFCAA) Schedule Estimating Relationships
- FRISK used to apply risk to life-cycle costs



Space Vehicle Cost Analysis



- Cost model outputs:
 - RDT&E
 - First unit cost
 - Additional unit cost
 - Total cost
- Heritage factors applied to RDT&E
- Bus and payload information used to generate total RDT&E
- Generated cost used to determine IA&T, PL and GSE cost
- Outputs broken down by WBS



Operations and Maintenance



CONOPS - -

File Edit View Defaults Help

COST MODEL(S)

- Vehicle0
 - Mission-Setup
 - Satellite
 - Fleet-Readiness
 - Availability
 - Facilities
 - Reliability-Survey
 - Surge Analysis
 - Labor
 - Training
 - Cost Summary

Model Name: Vehicle0

Mission Characterization

- ☒ Planned Launch Rate
- ☐ Prompt Global Strike
- ☐ On Alert
- ☐ Operationally Responsive Space

Operational Support (Yrs) 0

Start Year 0

☒ Then Year

☐ Base Year

Schedule

Days/Week ☐ 5 ☐ 6 ☐ 7

Shifts/Day ☐ 1 ☐ 2 ☐ 3

Hours/Shift ☐ 8 ☐ 10 ☐ 12

Sync Schedule to MissionOps

Vehicle Configuration

Vehicle Type: Expendable # Stages: 0

Stage 1 Type: Liquid

Strap On

Type ☒ Solid ☐ Liquid

Number of Stages: 0

☐ Parallel Burn

Launch Location: Cape

Values History

Values History Comments

Page Comments

Old Comments Add Page Comments

Submit

Change IPAT Vehicle

Advanced Cost Model

Acquisition Strategy: Normal Development and Production

AUC-Procurement (\$Millions) 0 AUC-Production (\$Millions) 0

AUC-Development (\$Millions) 0 Total Launch Costs (\$Millions) 0

IPAT

Vehicle Type: Expendable	Number of Boosters: 0	Number of Stages: 0	Boosters Reusable: No
Stage 1 Type: Liquid	Stage 1 Weight (lbm): 0	Stage 1 Length (ft): 0	Stage 1 Diameter (ft): 0
Stage 2 Type: Liquid	Stage 2 Weight (lbm): 0	Stage 2 Length (ft): 0	Stage 2 Diameter (ft): 0
Stage 3 Type: Liquid	Stage 3 Weight (lbm): 0	Stage 3 Length (ft): 0	Stage 3 Diameter (ft): 0
Stage 4 Type: Liquid	Stage 4 Weight (lbm): 0	Stage 4 Length (ft): 0	Stage 4 Diameter (ft): 0
Strapon Type: Solid	Strapon Weight (lbm): 0	Strapon Diameter (ft): 0	Parallel Burn: No
Payload Weight (lbm): 0	Payload Length (ft): 0	Shroud Weight (lbm): 0	Shroud Diameter (ft): 0
Max Wind Speed (kts): 0			

OK Cancel

Distribution A: Approved for Public
release (PA#)



Operations and Maintenance



COST MODEL(S)

Vehicle0

- Mission-Setup
- Satellite
- Fleet-Readiness
- Availability
- Facilities
 - Size

Cost Detail

Total Summary in Millions of Dollars

Total Facility Cost 904.093

COST MODEL(S)

Total Number of Flights 100

Number of Prior Flights 0

Run Failure Rate Analysis

	Flights	Failure Rate	Exp. Failures
Test Flights	5	0.53	2.64
Start up	10	0.36	3.55
Growth	25	0.19	4.72
Mid Life	60	0.08	4.95
Maturity	0	0.04	0.00

Total Exp. Failures 15.85

Roads and Grounds	\$ 0	\$ 9.9329	\$ 9.9329
Specialized Equipment	\$ 2.3284	\$ 0	\$ 2.3284

Distribution A: Approved for Public
release (PA#)



Previous Studies (cont'd)

Stage	Nominal Dry Weight (lbm)	Achieved Dry Weight (lbm)	Weight Difference (lbm)	Nominal Loaded Weight (lbm)	Percent Difference (% total stage weight)
Minotaur I Second Stage	1524	1753	229	15,506	1.5
Minotaur I First Stage	4,955	5,055	100	50,885	0.2

Four Launch Vehicles Modeled In ISCM
Delta II, Atlas V, Minotaur I, Falcon 1
Modeled weights within 2% of published values

Integrated Project Team

ISCM Tool

- Cost
- Risk
- CONOPS
- Schedule
- Operability
- Performance

Knowledge Database Buildup

TacSat -5 Concept Evaluations

Thirteen Concepts for TacSat – 5 Evaluated Using Tool Suite

Identified requirements not met and inaccurate understated estimates

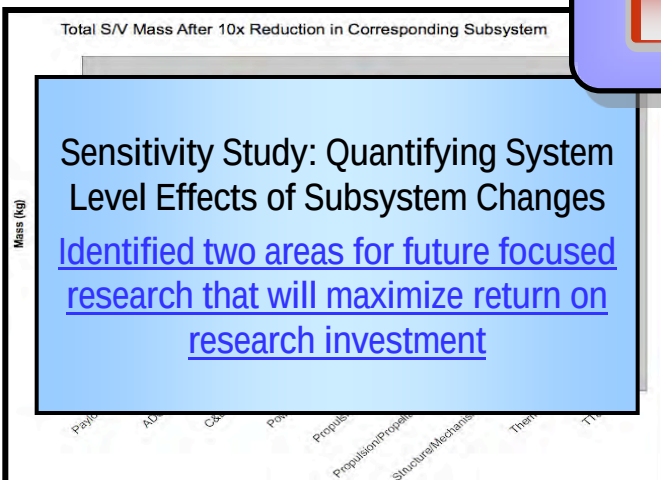
Contained questionable assumptions that needed further investigation

Results

ORS Seven Sisters Mission Cost

Procurement and total mission cost estimate for ORS missions and launch scenarios –

Completed in less than 7 days
Within 5% of other independent estimates

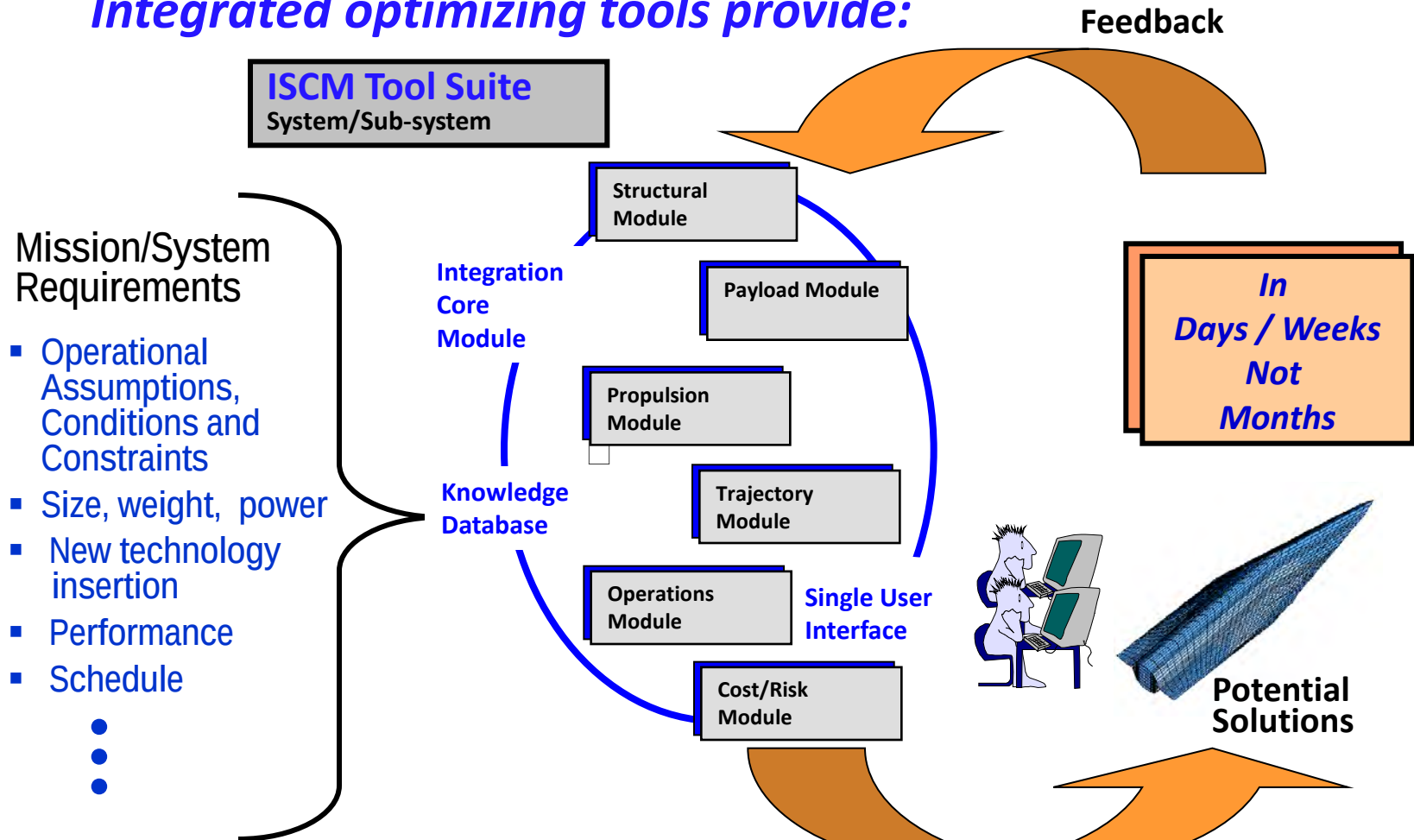




Summary

Solution to Early Design Challenges of High-Performance Complex Systems

Integrated optimizing tools provide:



Distribution A: Approved for Public
release (PA#)



Future Work

- Improved trajectory optimization for heavily constrained problems
- Enhanced mass estimating relationship
- Increase fidelity of risk assessment
- Improve historical data
- Model additional vehicle classes:
 - Aircraft
 - Rotorcraft
 - Armored vehicles
 - Transport vehicles
 - Communication networks



Questions?



Distribution A: Approved for Public
release (PA#)