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A Next Generation Launch Capacity Model For the U.S. Eastern Range

2nd NRO/AIAA Workshop on Space Launch Integration

May 2-4, 2000

Presented By:
David H.W. Steare
TSO Team
steared@mit.edu

Research Sponsored By LAI

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Outline

- Background of USAF Range Capacity Modeling Effort
- Scope of Range "Capacity"
- Advanced System Dynamics Modeling Effort

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Range Capacity Model (RCM) Background

The current USAF RCM is a power tool! (v8.2)

- **Created to assist Air Force planning personnel and policy makers (March 1998)**
- **Spreadsheet equations model key launch and range operations variables**
- **It has contributed to:**
  - **Lt. General Henry IPT Report, 1998**
  - **Congressional National Launch Capabilities Study, 1999**
  - **White House IAWG Study, 1999**

…but it <u>can</u> & <u>should</u> be enhanced!

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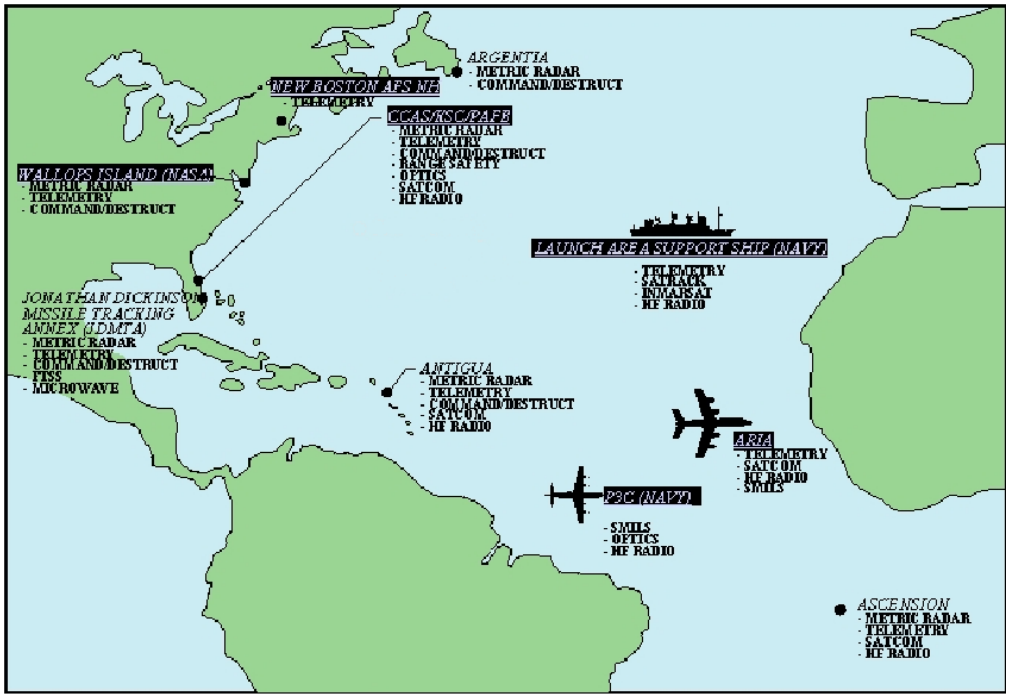
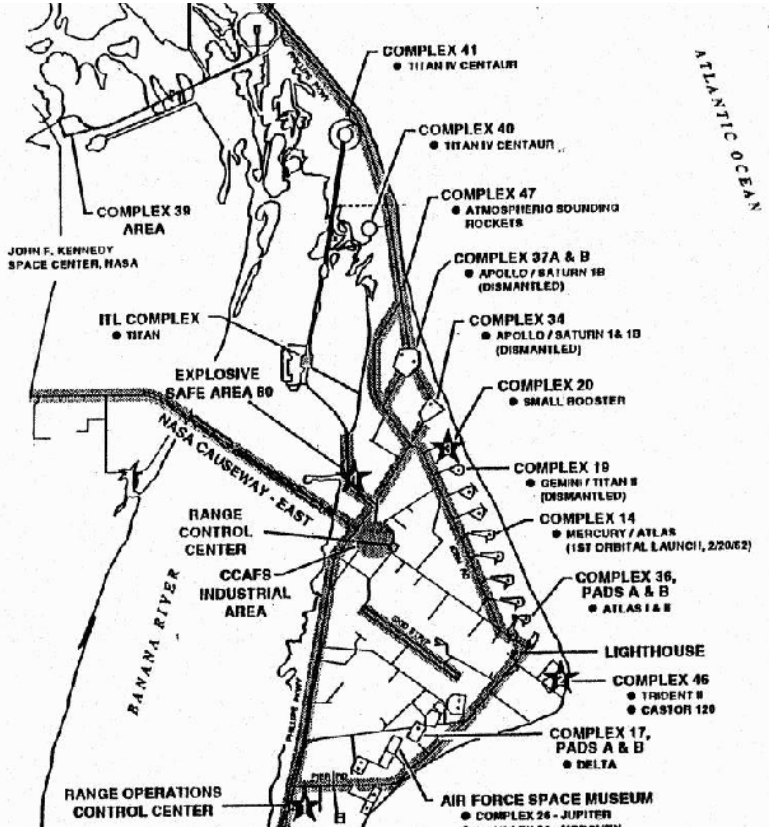
Capacity Model Boundaries

- **Outer Boundary= ER**
  - Incorporates notion of down range stations and assets



- **Inner Boundary**
  - Multiple launch pads



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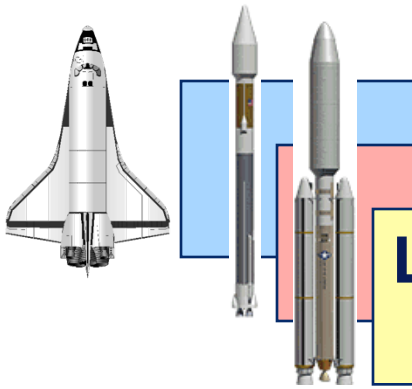
Basic Concept of Range Launch Operations



Answer

Launch Vehicle/ Pad Ops

Request for Support

Range Support Allocation

Range Downtime

Range Crew Workload

Range Systems Maintenance

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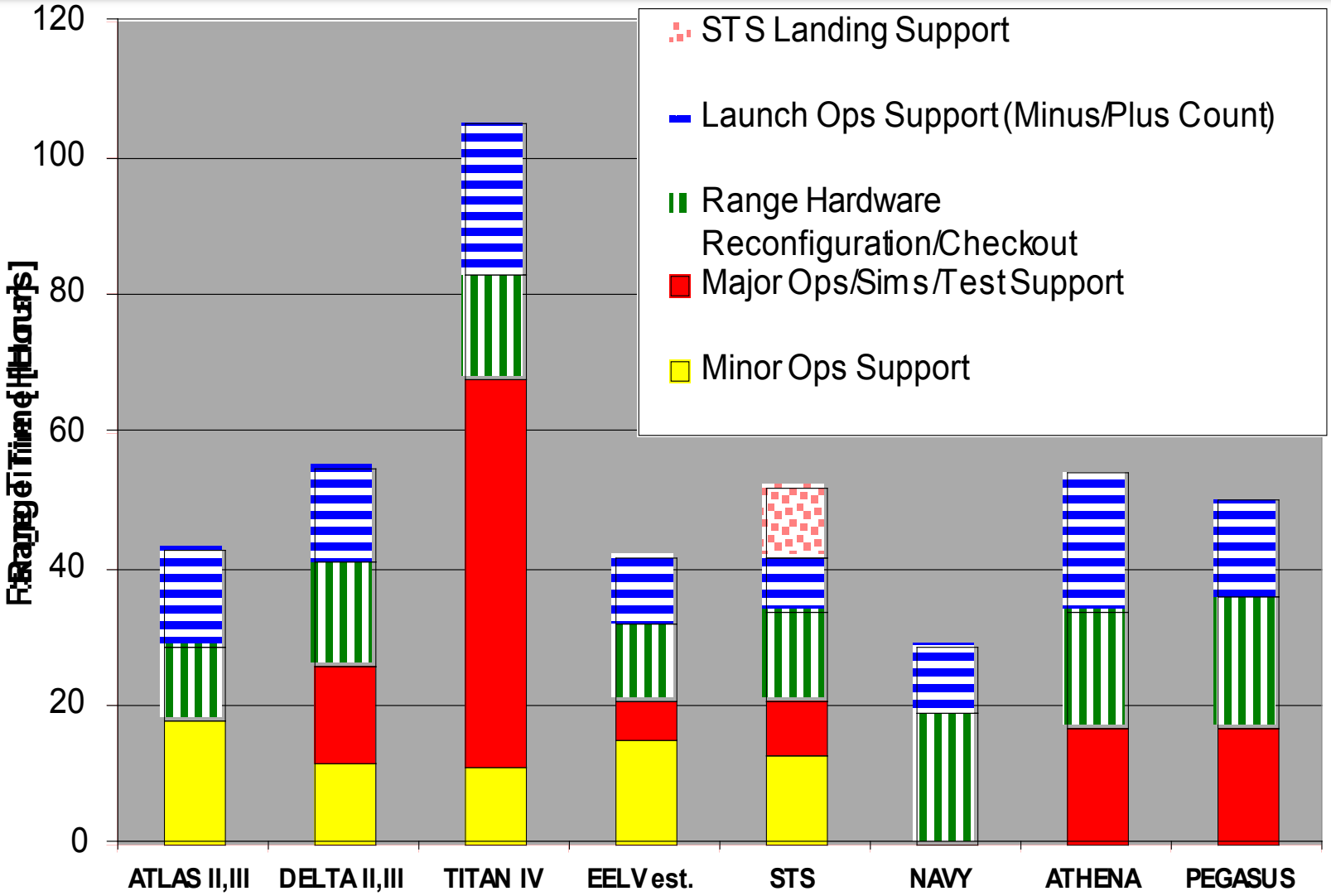
Eastern Range Support Requirements



*Nominal Times-- Not including scrubs, slips, or crew limitations, Data Source: ER Ops Directives, 45SW and Launch Program Interviews

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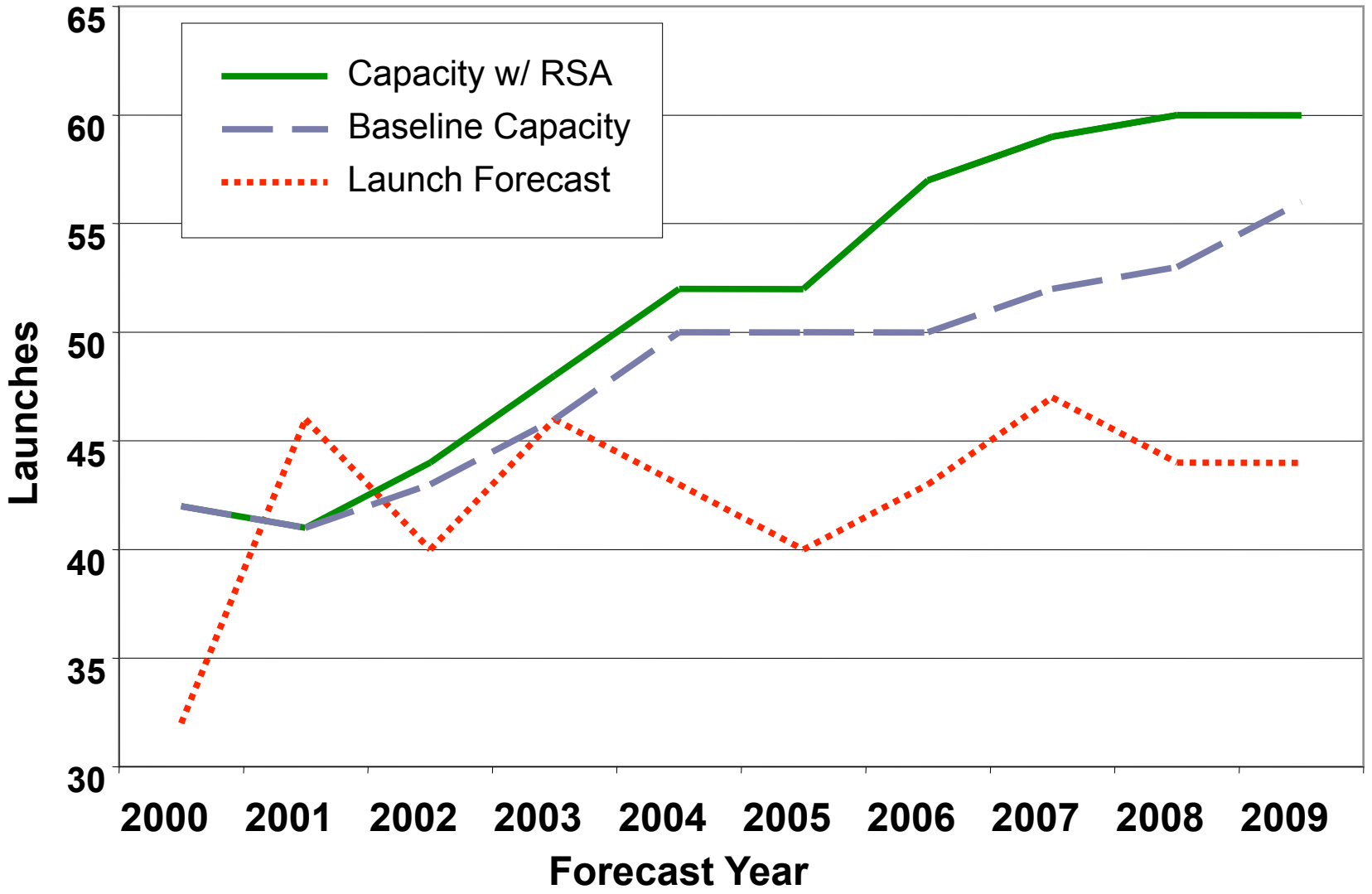
Example of USAF Past RCM Projections



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Accepted USAF Model

- Spreadsheet methods
- Launch capacity derived from time requirements of the following cumulated factors:
  - Durations of Ops Support
  - Scheduling Changes
  - Minor Ops Impact
  - Maintenance Impact
  - Range Downtime
  - Personnel Limitations

	FY-2000	
MAJOR OPS	Number/Launch	Range Days/Launch
Launches	1.00	0.57
Sims/Wet Dress	2.44	0.58
STS Landings	0.28	0.12
Landing Scrubs	0.03	0.01
F-1s	1.13	0.67
Launch Scrubs	0.53	0.30
	5.41	2.25
SCHEDULING CHANGES*	Number/Launch	Range Days/Launch
Customer Reschedules	4.41	1.91
Range Reschedules	0.26	0.11
Other Reschedules	0.44	0.19
	5.11	2.21
MINOR OPS IMPACT	Days Impact	Range Days/Launch
365 Day Operations	7.56	0.18
MAINTENANCE DOWNTIME	Days Impact	Range Days/Launch
365 Day Operations	3.36	0.08
RANGE PMI/DOWNTIME	Days Impact	
Non-Launch Programs Support	10	
Holiday	5	
Modernization	15	
ROCC Downtime	5	
Additional Downtime	5	
	40	
PERSONNEL LIMITATIONS		Range Days/Launch
RTS Personnel Crew Rest		3.04
TOTAL COMMITMENTS	365.92	7.76
TOTAL RANGE CAPACITY	**42 Launches**	

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System Dynamics? A Quick Background

- **Definition-**
  - **A modeling methodology that combines theory and computer simulation with a practical application to real-world problems**
- **Field was founded in 1956 by Jay Forrester at MIT**
- **Focuses on the way internal feedback-loop relationships cause a system to change through time**
- **Motivation**
  - **Understanding why a system behaves as it does permits redesign of *structure* and *policies* to improve *behavior***

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Advanced Modeling Approach Using System Dynamics

For each simulated hour of the year, the model:

1) Determines current time
2) Checks range status for ops restrictions
3) Calculates need for crew rest
4) Accounts for rescheduling effects
5) Performs range systems maintenance as necessary
6) Prioritizes and allocates support for launch ops

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Layout of the Advanced Range Capacity Model

Time Functions

Planned Restricted Days

Crew Rest

Range Systems Maintenance

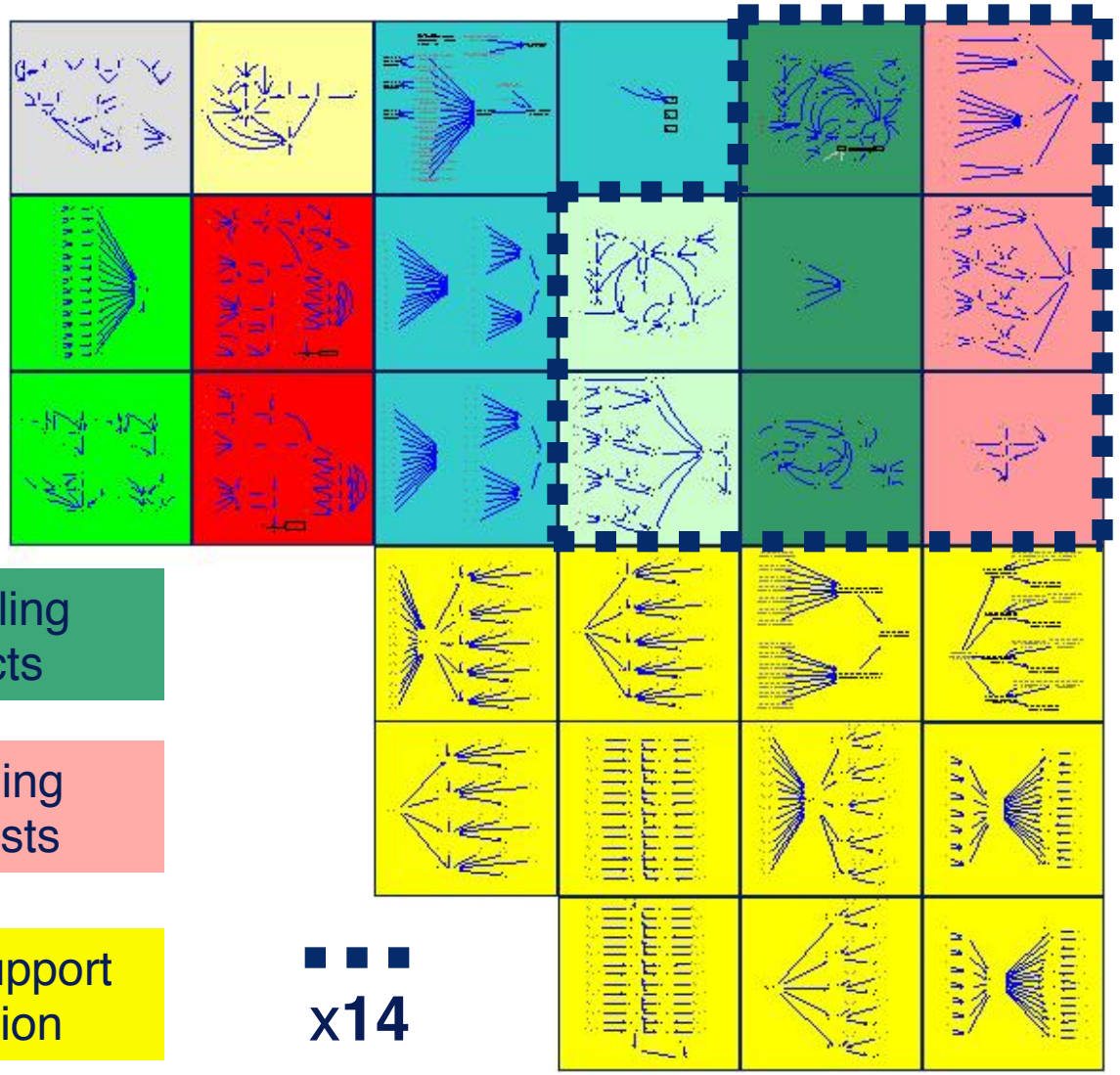
Scheduling Impacts

Range Statistics

Prioritizing Requests

Launch Vehicle Operations

Range Support Allocation



x14

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Model Complexity

- Current version accommodates up to 14 launch pads (simultaneous launch flows)
- ~2,000 Unique visible variables
- ~70,000 Total unique variables
- ~40 minute maximum run time to simulate a single year hour by hour (Pentium II, 300Mhz)
- ~600M explicit values calculated during a simulation

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Model Section Example: Launch Vehicle Operations

- **Real World Behavior**
  - 2 types of launch operations requiring range support: Major & Minor Ops
    - Major ops require significant range support resources
    - Range can only support one *Major op* at a time
    - Minor ops require lower amounts of range support
    - Range can support simultaneous *Minor ops*
- **Modeling Approach**
  - Incorporate nominal "launch span" characteristics for each type of launch vehicle

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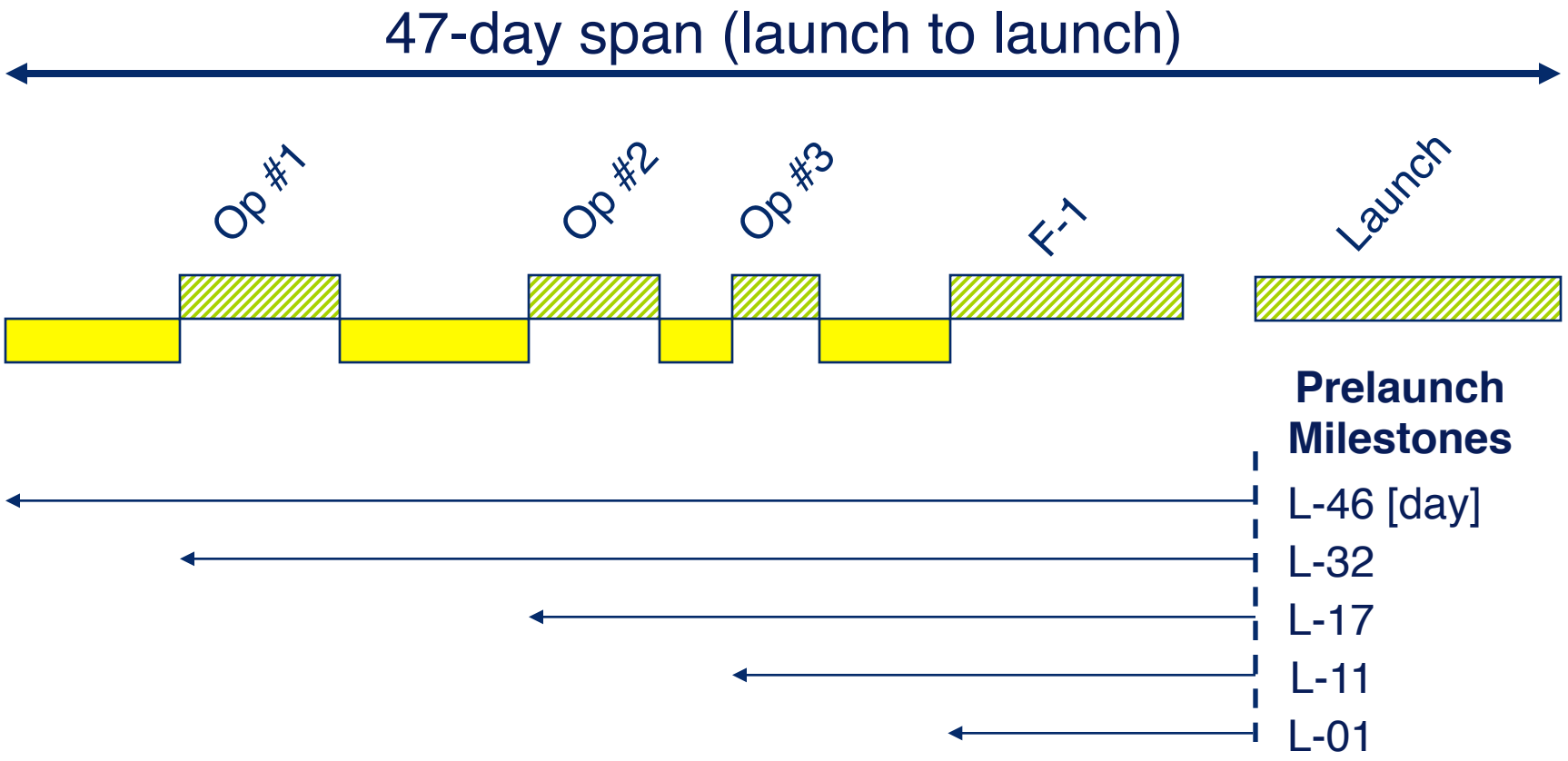
Program 'X' Launch Span (Example Campaign)

Range Support Activity =10 hours

Launch Program Range Independence =10 days



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Comparison of Launch Operations Fidelity

USAF Accepted Model

- Major Ops
  - Duration
- Minor Ops
  - Aggregate Duration

Advanced Model

- Major & Minor Ops
  - Name
  - Duration
  - Sequence
  - Timeline

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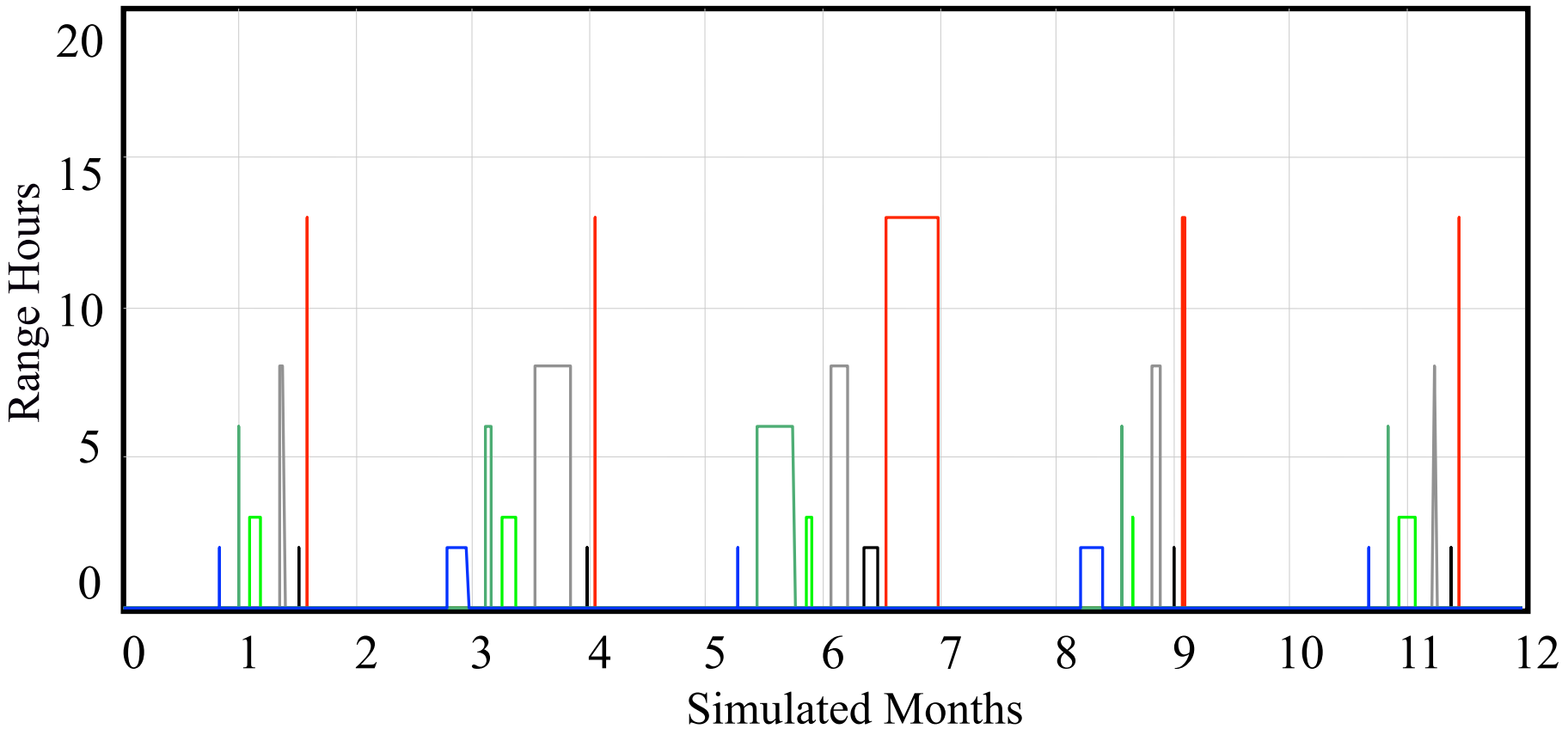
Example Plot: Launch Pad 'A' Support Requests



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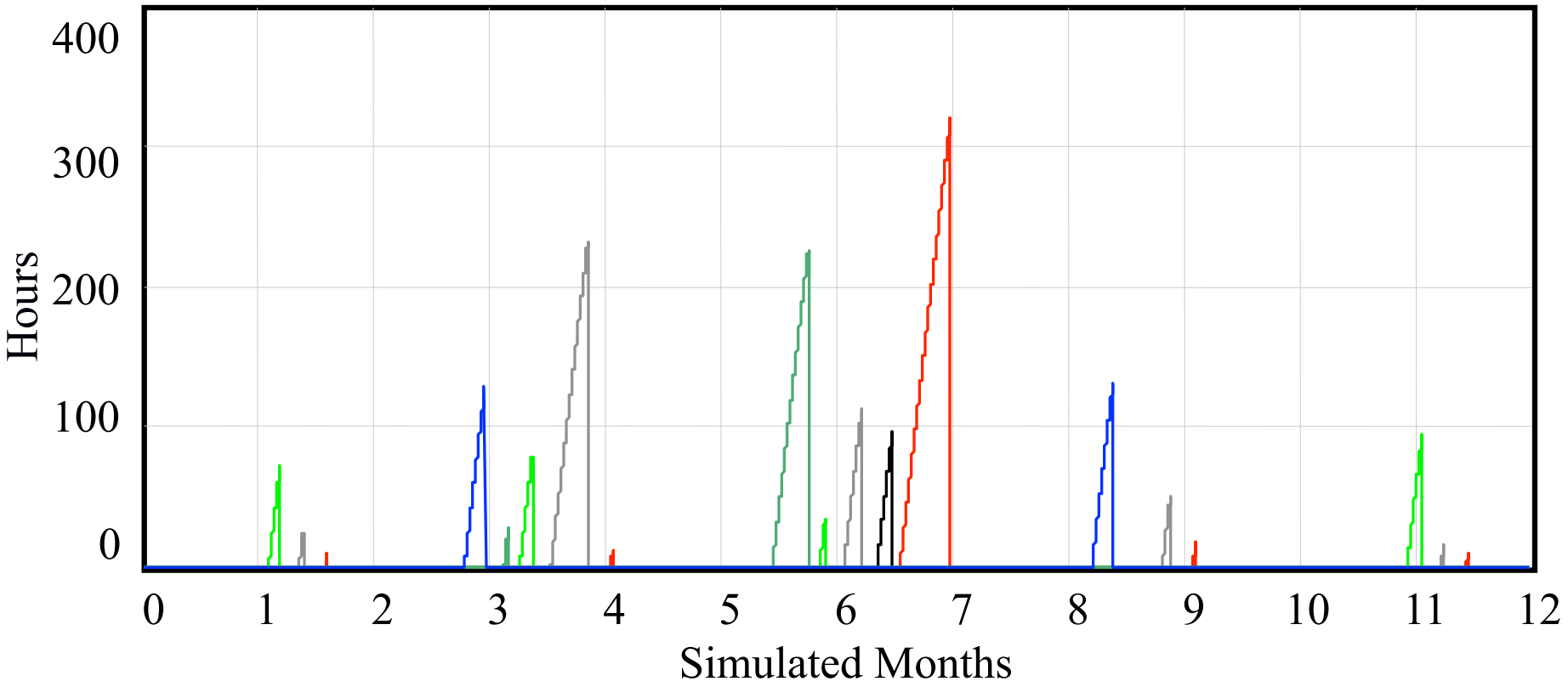
Example Plot: Launch Pad 'A' Request Wait Times



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Model Section Example: Crew Rest

- **Real World Behavior**
  - *Contracted single range crew
  - Workload restrictions (OSHA, range safety, unions)
- **Modeling Approach**
  - Directly incorporate the three workload “guidelines”
    - No more than 12 hours per day
    - No more than 60 hours per workweek
    - No more than 14 consecutive workdays without a 24-hour break

*pending implementation of a reconfiguration “core crew”

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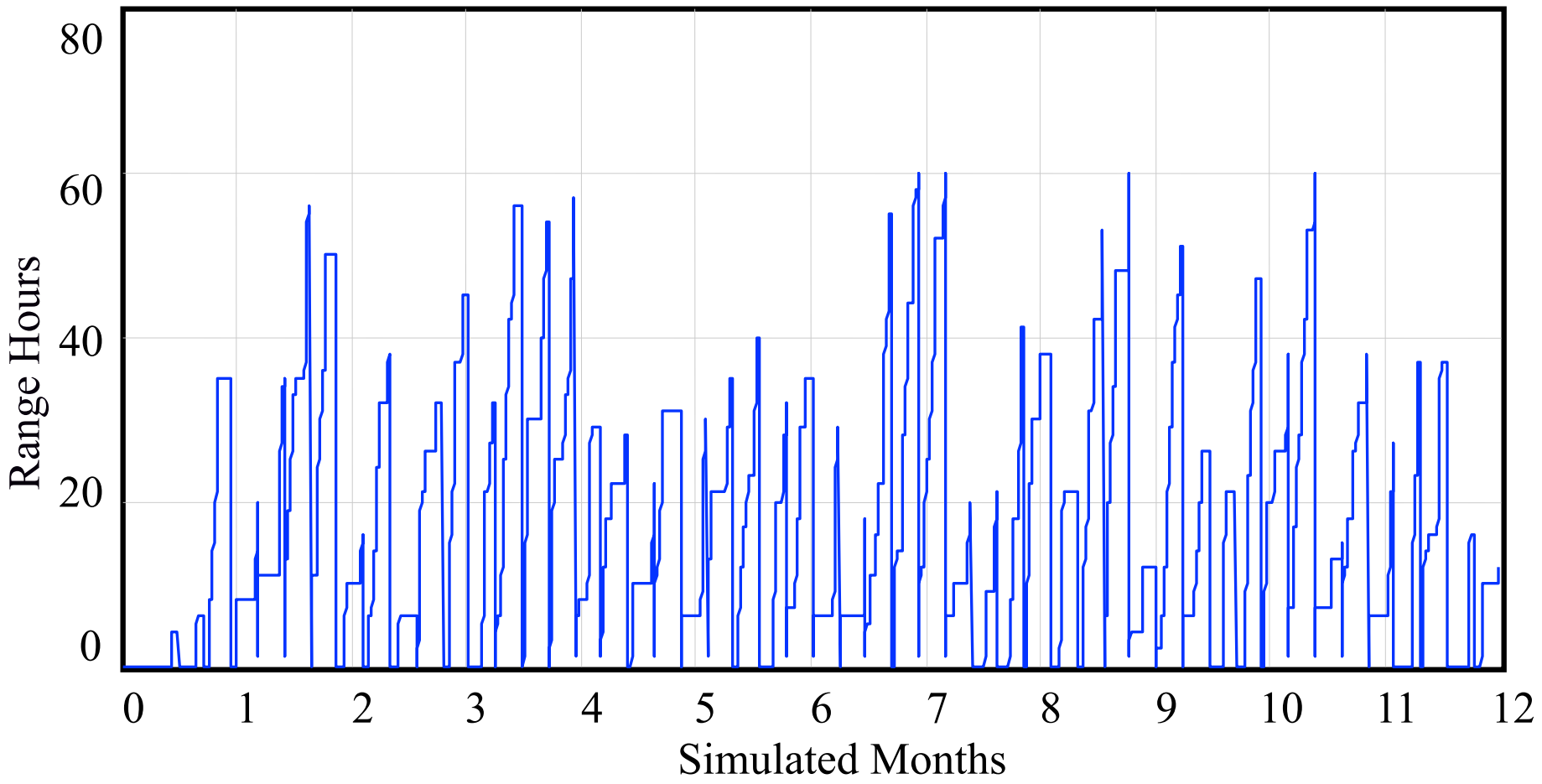
Example Plot: Range Crew Weekly Launch-related Workload



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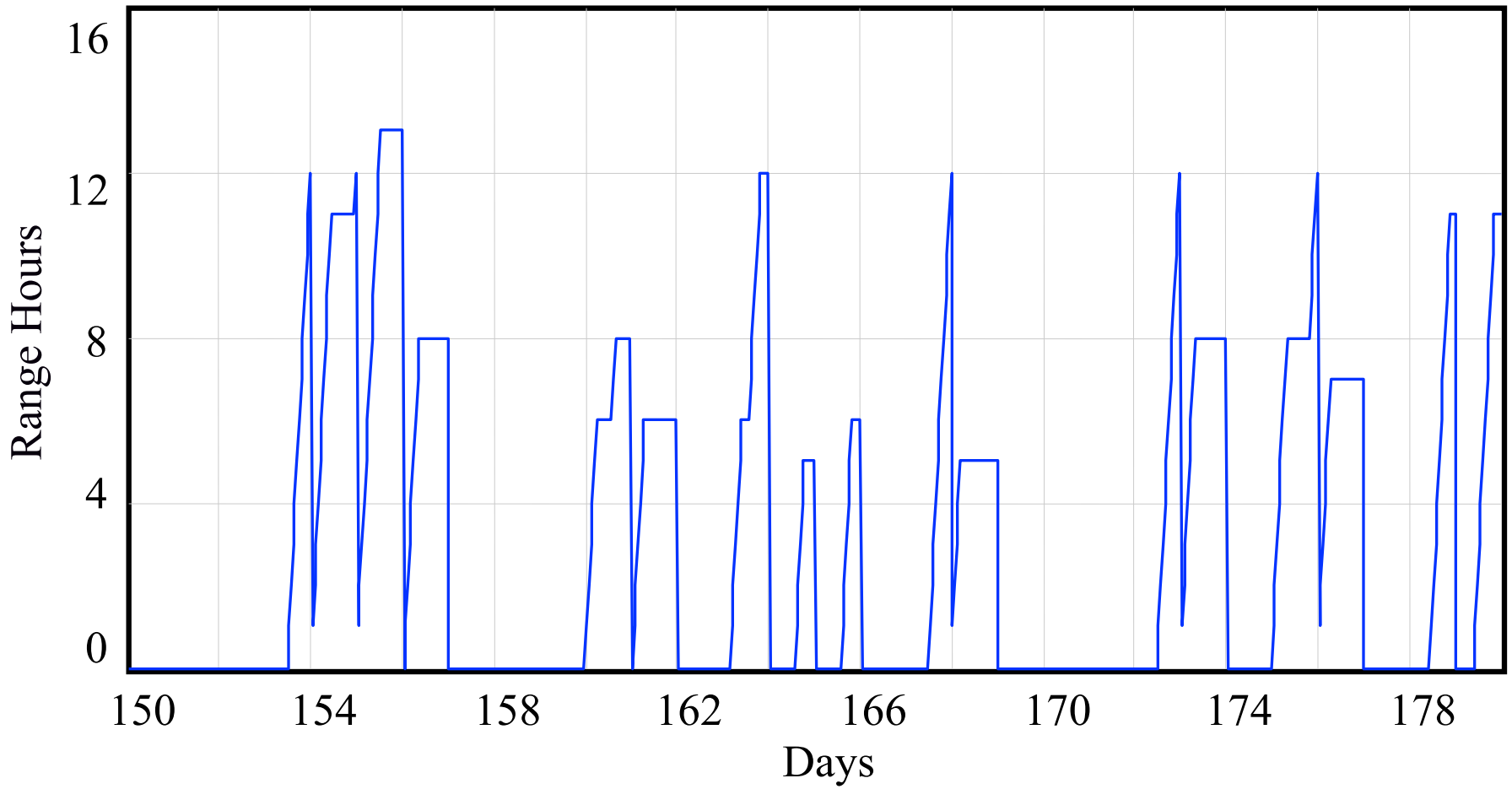
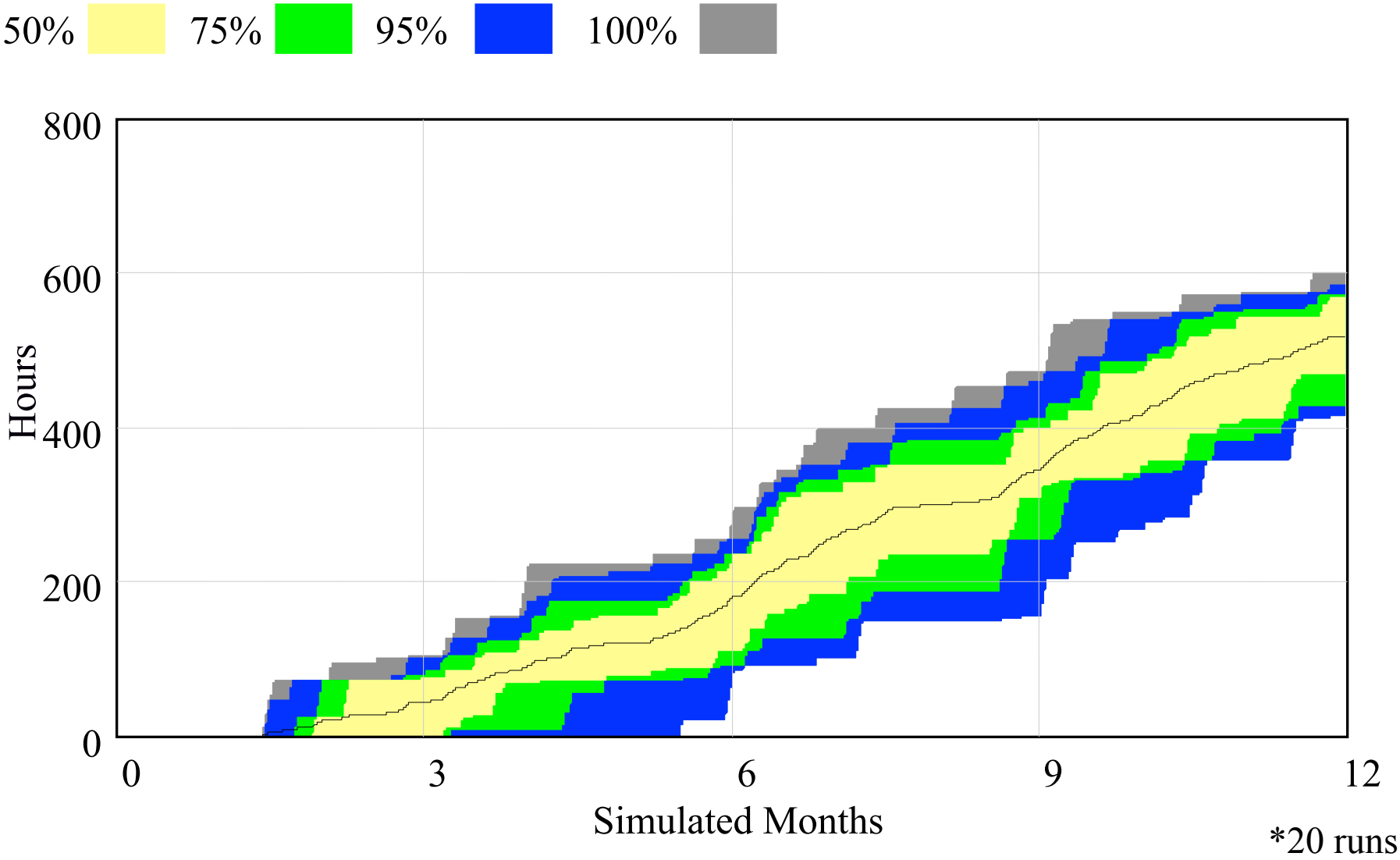
Example Plot: Range Crew Daily Launch-related Workload



Example Plot: Variable Maintenance Time



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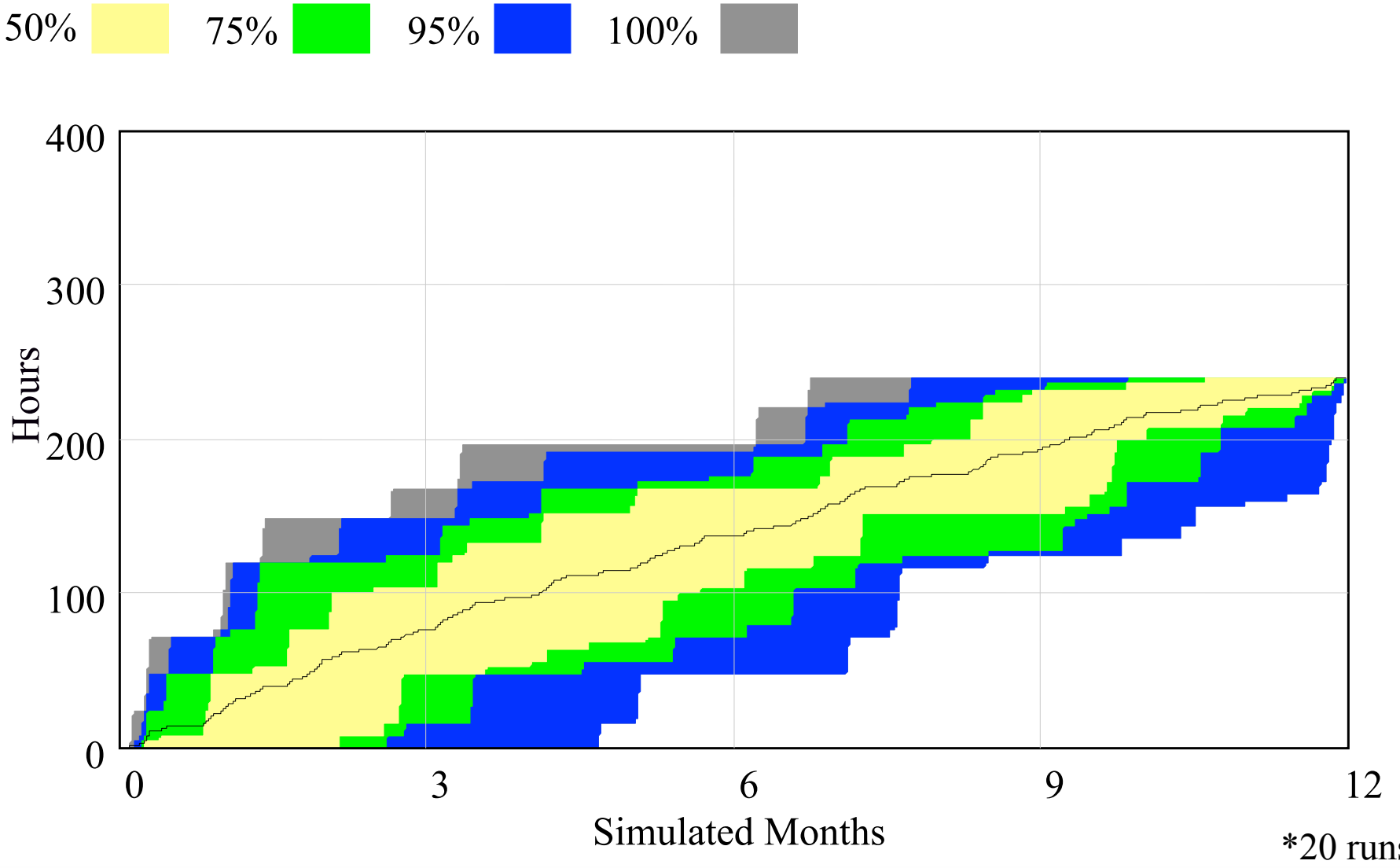
Example Plot: Fixed Maintenance Time



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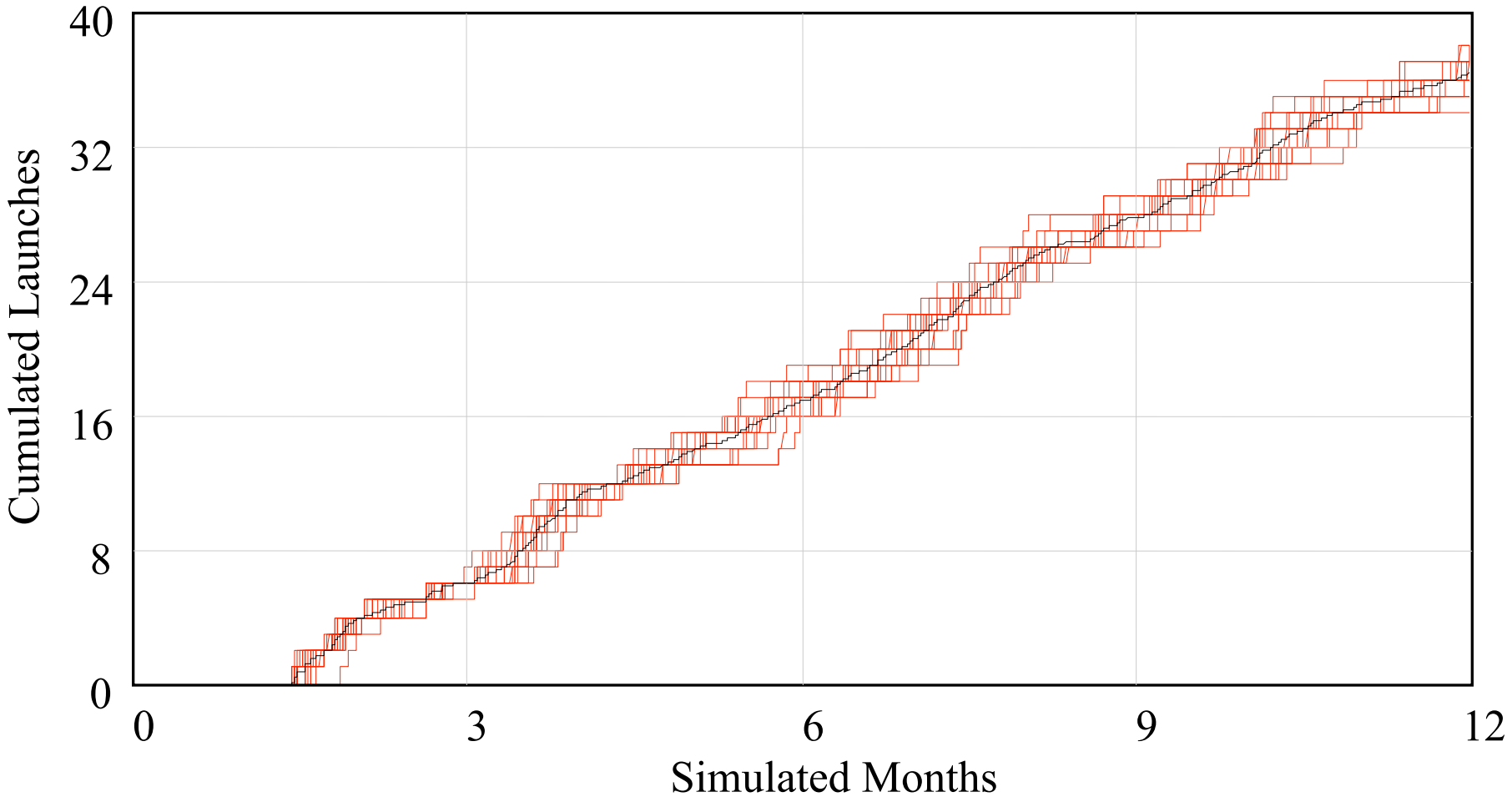
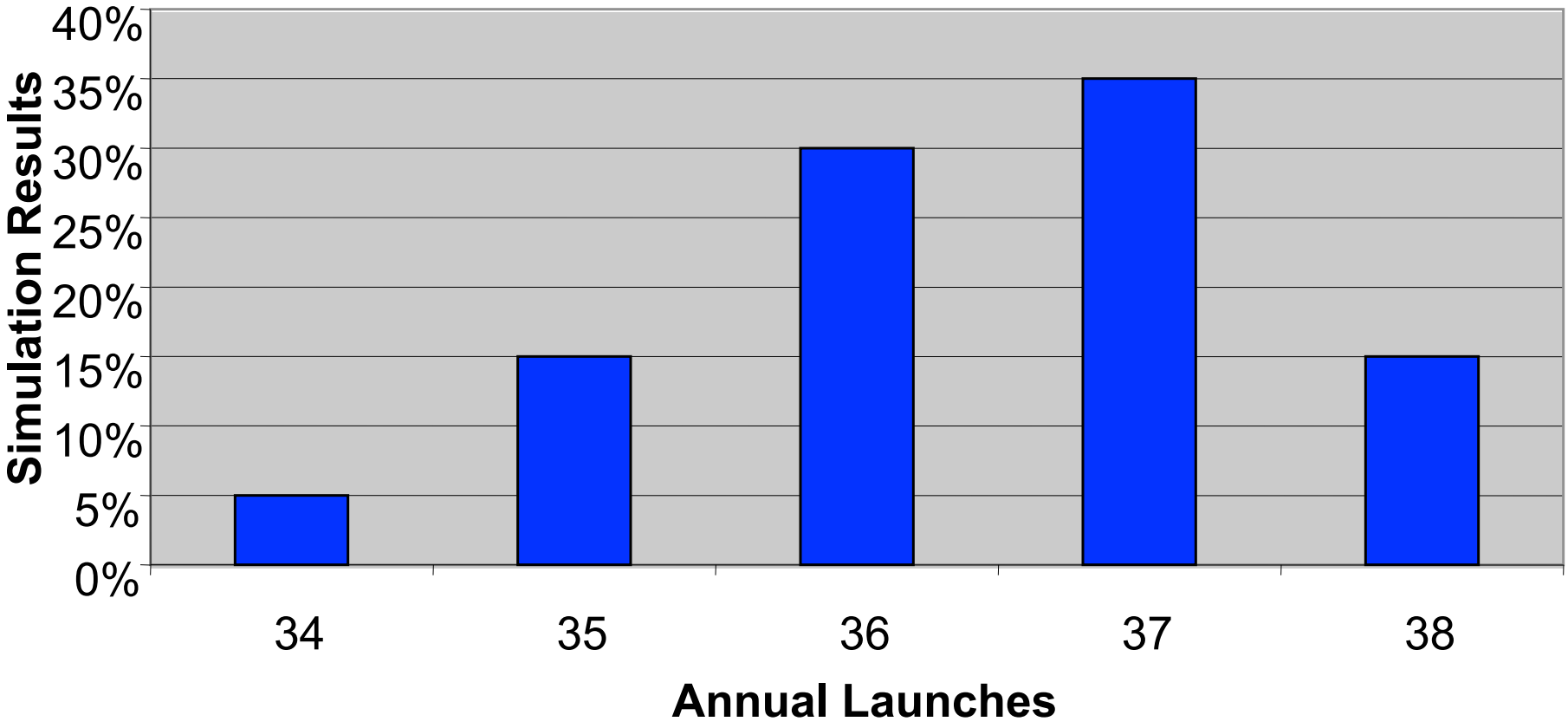
Example Plot: Cumulated ER Launches



*20 runs

Example Plot: Expected ER Launches



National Launch Forecast = 44

USAF Range Capacity Modeling Approach = 45

*20 runs

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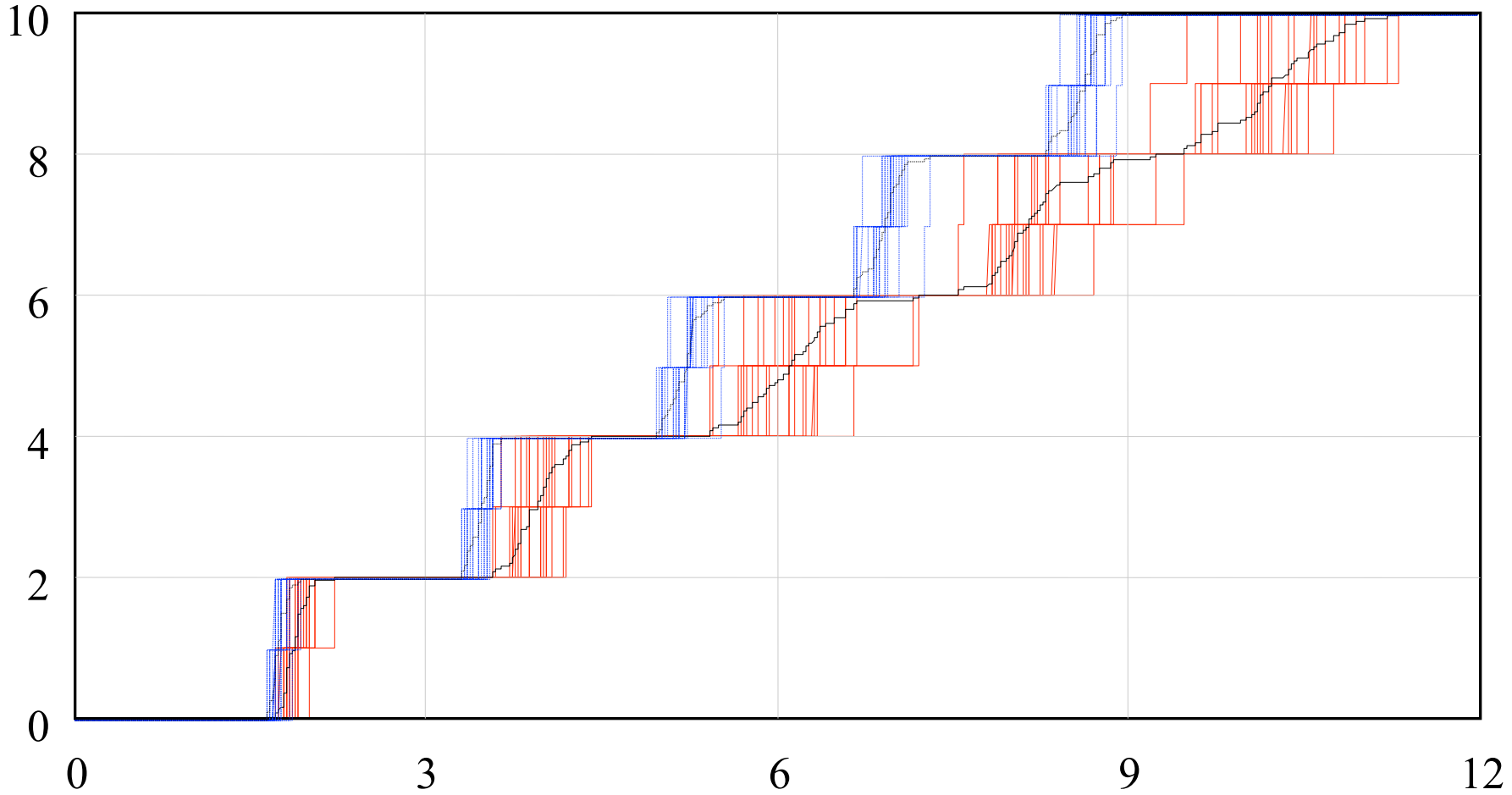
Example Plot: Vehicle 'X' Cumulated Launches



*20 runs

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The Research Plan

- Model development *primarily completed
- Initial phase of analysis
- Soliciting feedback from
  - Eastern Range and other government interests
  - Launch programs
- Produce recommendations and complete thesis by August

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BACKUP MATERIAL

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Some Advantages of System Dynamics

- Units are required for all values
  - Increases comprehension
  - Verifies equations
- Helpful comments are readily available onscreen
  - Displays definitions, units...
  - Used for verifying logic
  - Constantly updated documentation of variables
- Probability distributions can be assigned to reflect confidence levels and uncertainty
  - Applicable to scrub rates, rescheduling rates, launch manifest...
- Software offers built-in sensitivity and optimization tools

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Additional Strengths of System Dynamics Approach

***System Dynamics* modeling:**

Provides a visual map for tracing cause & effects

- **Accounts for feedback relationships and completes the "open loops"**
- **Conducive to running "what if" scenarios**
  - **Excellent tool for decision makers, business planners, and policy analysts**
- **Aids the understanding of complex systems**

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Generic Launch Timeline