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A Comparative Analysis of Nuclear Security Enterprise Estimates

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Unclassified Unlimited Release

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U.S. DEPARTMENT OF ENERGY | NNSA

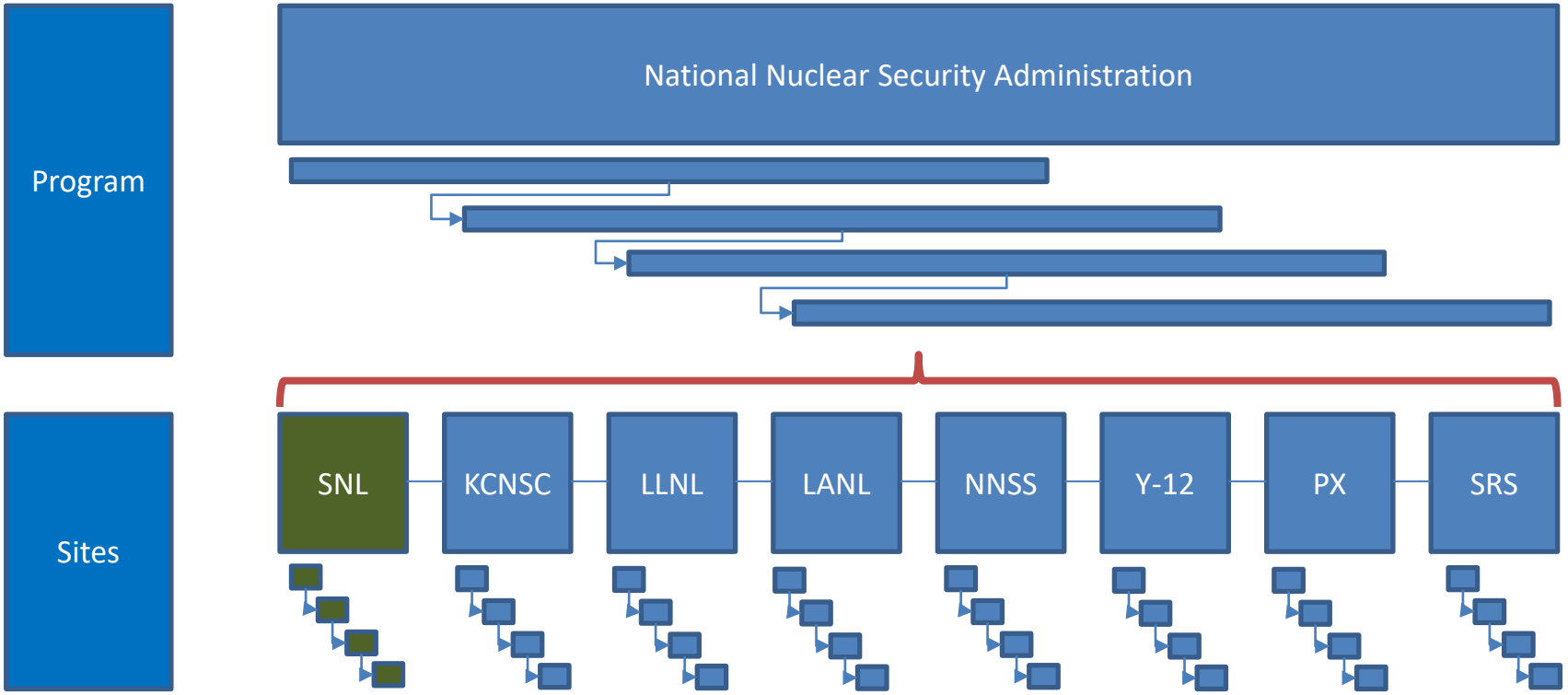
Agenda

- Objectives (1 -2 minutes)
- Background (10 – 15 minutes)
  - Nuclear Security Enterprise
  - Life Extension 6.X Process
- Model Concept (5 – 10 minutes)
  - Data, Methods, Approaches, and Techniques
- Comparative Analysis (2 – 3 minutes)
- Discussion (5 – 15 minutes)

Objectives

- Share perspectives and a use-case regarding Nuclear Weapon data and estimating
- Exchange cost related knowledge with other defense programs regarding conventional and classified cost estimating practices
- Share contact information, engage in dialogue, and develop relationships for collaborative efforts

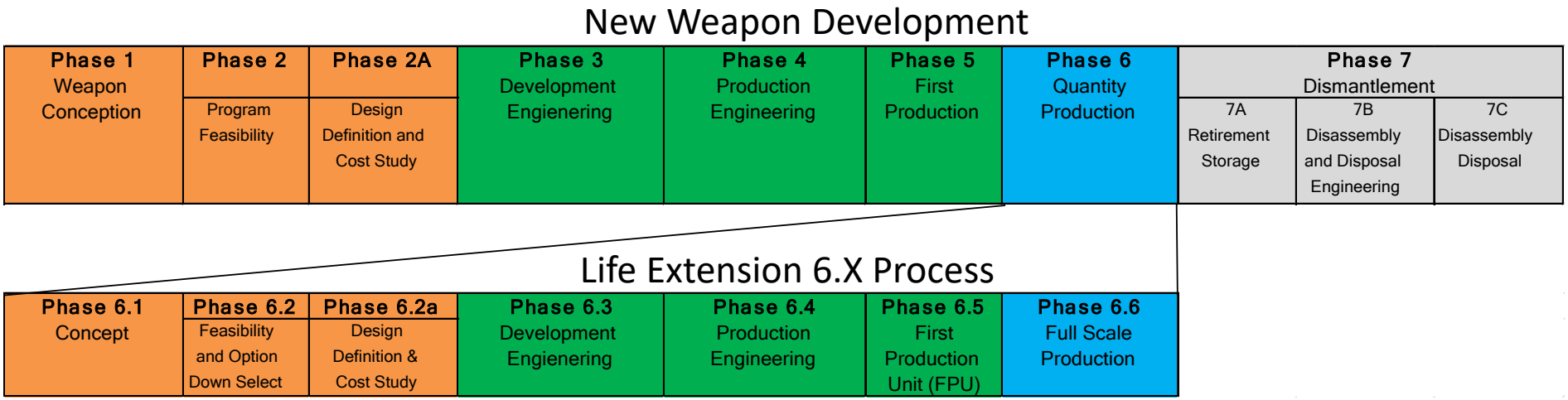
Background



- Sandia National Laboratories – Responsible for nuclear weapon systems and components over their entire lifecycle, from original design through final dismantlement and disposal. Responsibility includes design, qualification, certification, and assessment of the non-nuclear subsystems and system qualification as well as integration with delivery vehicles.
- The nation's nuclear weapons must *always* work when commanded and authorized by the President of the US and must *never* detonate otherwise.

https://www.sandia.gov/missions/nuclear_weapons/index.html
https://www.energy.gov/nnsa/articles/nnsa-awards-sandia-national-laboratories-management-operating

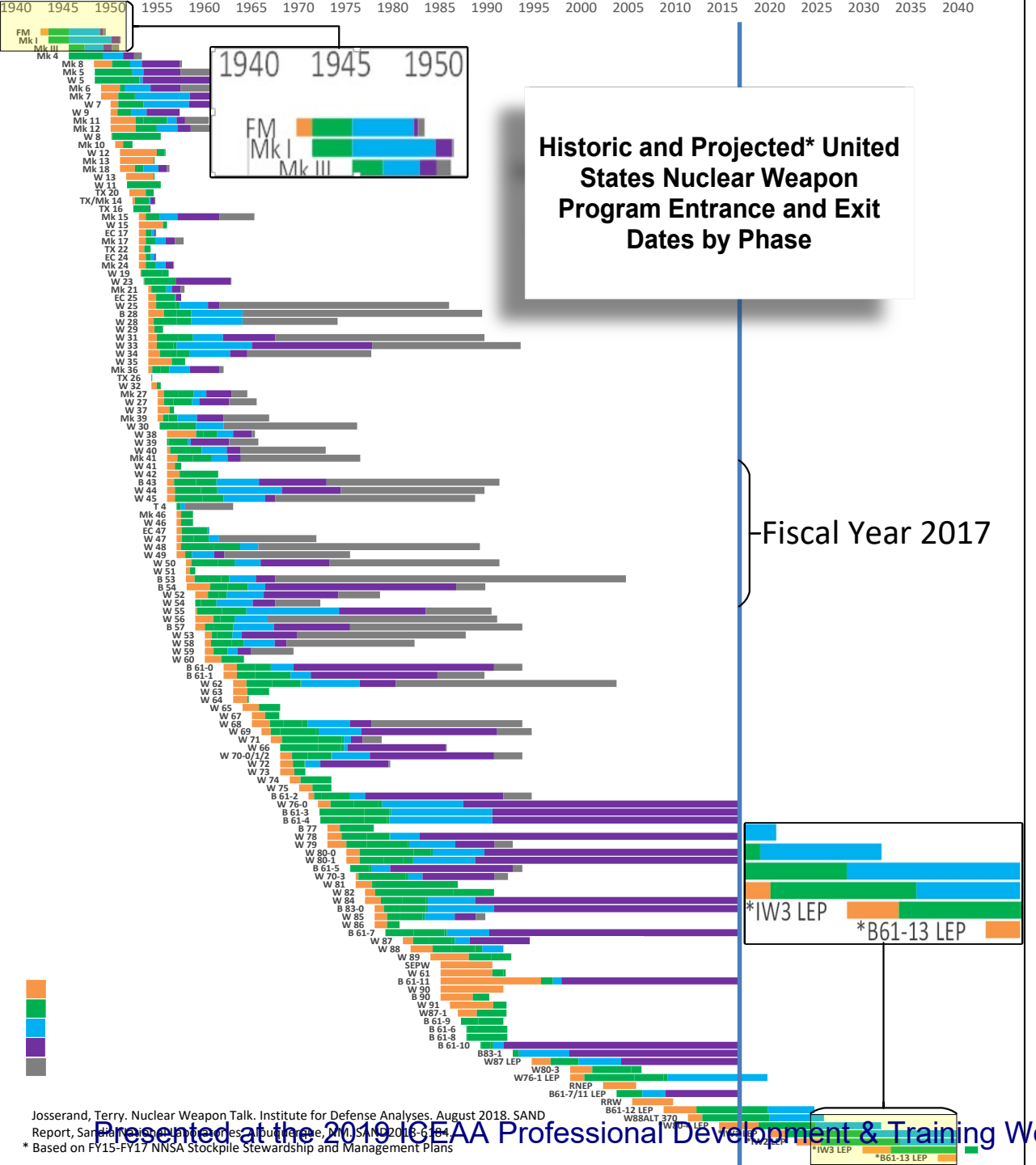
Background Nuclear Weapon Product Lifecycle



- Traceable historic and projected United States nuclear weapon program entrance and exit dates by phase

Josserand, Terry and Young, Z. Leone and Chamberlin, P. Edwin, Building Foundations for Nuclear Security Enterprise Analysis, SAND2017-10660

Background



30 years in 2020 since the last new weapon entered development engineering

30 years in 2019 since the last new weapon entered production

1979 Honda Civic

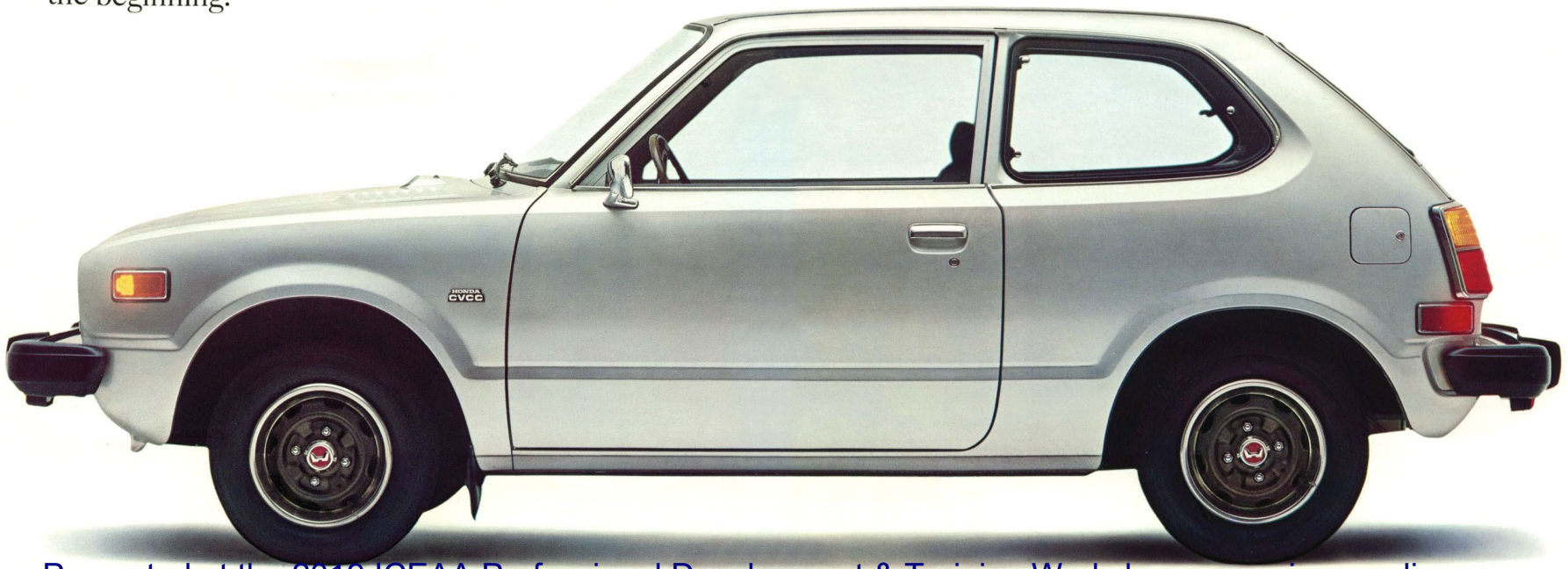
The Honda Civic CVCC 5-Speed.

The Honda Civic CVCC 5-Speed is a car built for people who love to drive. The fifth gear is actually overdrive, which is just right for cruising at highway speeds.

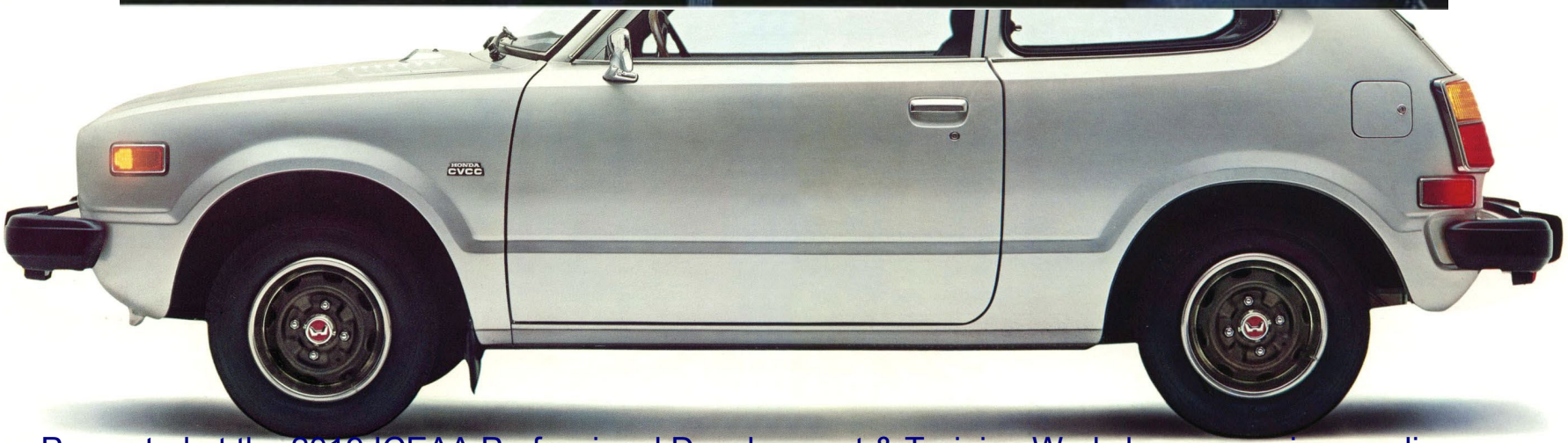
The Civic CVCC 5-Speed has many of the earmarks of a sports car. Four-wheel independent MacPherson strut suspension. Rack and pinion steering. Power-assisted front disc brakes. Steel-belted radial tires. A tachometer, red-lined at 6000 rpm. Plus front-wheel drive. But these features are just the beginning.

The fuel and temperature gauges are arranged in a compact, easy-to-see layout. So you don't have to crane your neck to check the gas level or temperature. And a combination light switch on the left side of the steering column controls the lights, including the headlight high-low beams.

The Civic CVCC 5-Speed comes with AM radio. Reclining front bucket seats with adjustable headrests. Full carpeting. Opening rear quarter windows. Tinted glass all around. Rear window defroster.



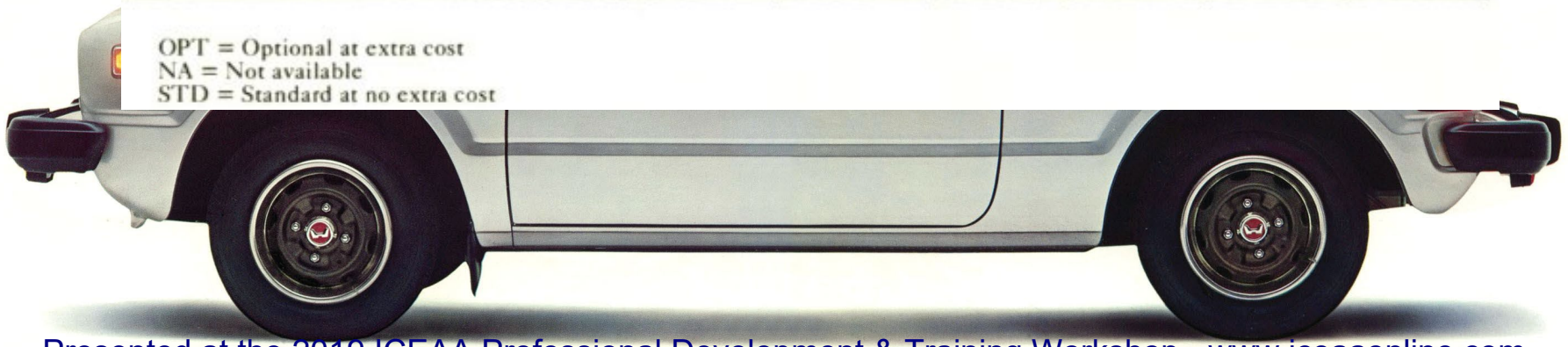
1979 Honda Civic



1979 Honda Civic

	Civic 1200 2-Dr. Sdn.	Civic 1200 Hatchback	Civic CVCC 2-Dr. Sdn.	Civic CVCC Hatchback	Civic CVCC 5-Speed	Civic CVCC Wagon
AM Radio	OPT	STD	OPT	STD	STD	OPT
AM/FM Radio	OPT	OPT	OPT	OPT	OPT	OPT
AM/FM Stereo Radio	OPT	OPT	OPT	OPT	OPT	OPT
AM/FM Stereo Radio with 8-Track Player	OPT	OPT	OPT	OPT	OPT	OPT
AM/FM Stereo Radio w/Cassette Player	OPT	OPT	OPT	OPT	OPT	OPT
MPX Stereo Speakers—Pocket	OPT	OPT	OPT	OPT	OPT	NA
MPX Stereo Speakers—Surface	NA	NA	NA	NA	NA	OPT
Wood Gearshift Knob	OPT	OPT	OPT	OPT	STD	OPT
Floor Mats—Color-Keyed	OPT	OPT	OPT	OPT	OPT	OPT
Tonneau Cover—Black	NA	OPT	NA	OPT	OPT	OPT
Body Side Decal Stripes	OPT	OPT	OPT	OPT	OPT	OPT
Air Conditioning	OPT	OPT	OPT	OPT	OPT	OPT
Cigarette Lighter	OPT	OPT	OPT	OPT	STD	STD
Intermittent Windshield Wiper	OPT	OPT	OPT	OPT	STD	OPT
Roof Console with Clock	OPT	OPT	OPT	OPT	OPT	OPT
Rear Window Wiper/Washer	NA	OPT	NA	OPT	OPT	NA
Rear Window Defroster	OPT	STD	OPT	STD	STD	STD
Luggage Rack	OPT	OPT	OPT	OPT	OPT	OPT
Fender Well Trim	OPT	OPT	OPT	OPT	OPT	OPT
Body Side Mouldings	OPT	OPT	OPT	OPT	OPT	OPT
Door Edge Guards	OPT	OPT	OPT	OPT	OPT	OPT
Front Bumper Override	OPT	OPT	OPT	OPT	OPT	OPT
Rear Bumper Override	NA	OPT	NA	OPT	OPT	NA
Rear Deck Slats	NA	NA	NA	NA	NA	OPT

OPT = Optional at extra cost
NA = Not available
STD = Standard at no extra cost



Honda Civic 1979 to 2019

New Weapon Development

Phase 1	Phase 2	Phase 2A	Phase 3	Phase 4	Phase 5	Phase 6	Phase 7		
Weapon Conception	Program Feasibility	Design Definition and Cost Study	Development Engienering	Production Engineering	First Production	Quantity Production	Dismantlement		
							7A Retirement Storage	7B Disassembly and Disposal Engineering	7C Disassembly Disposal

Life Extension 6.X Process

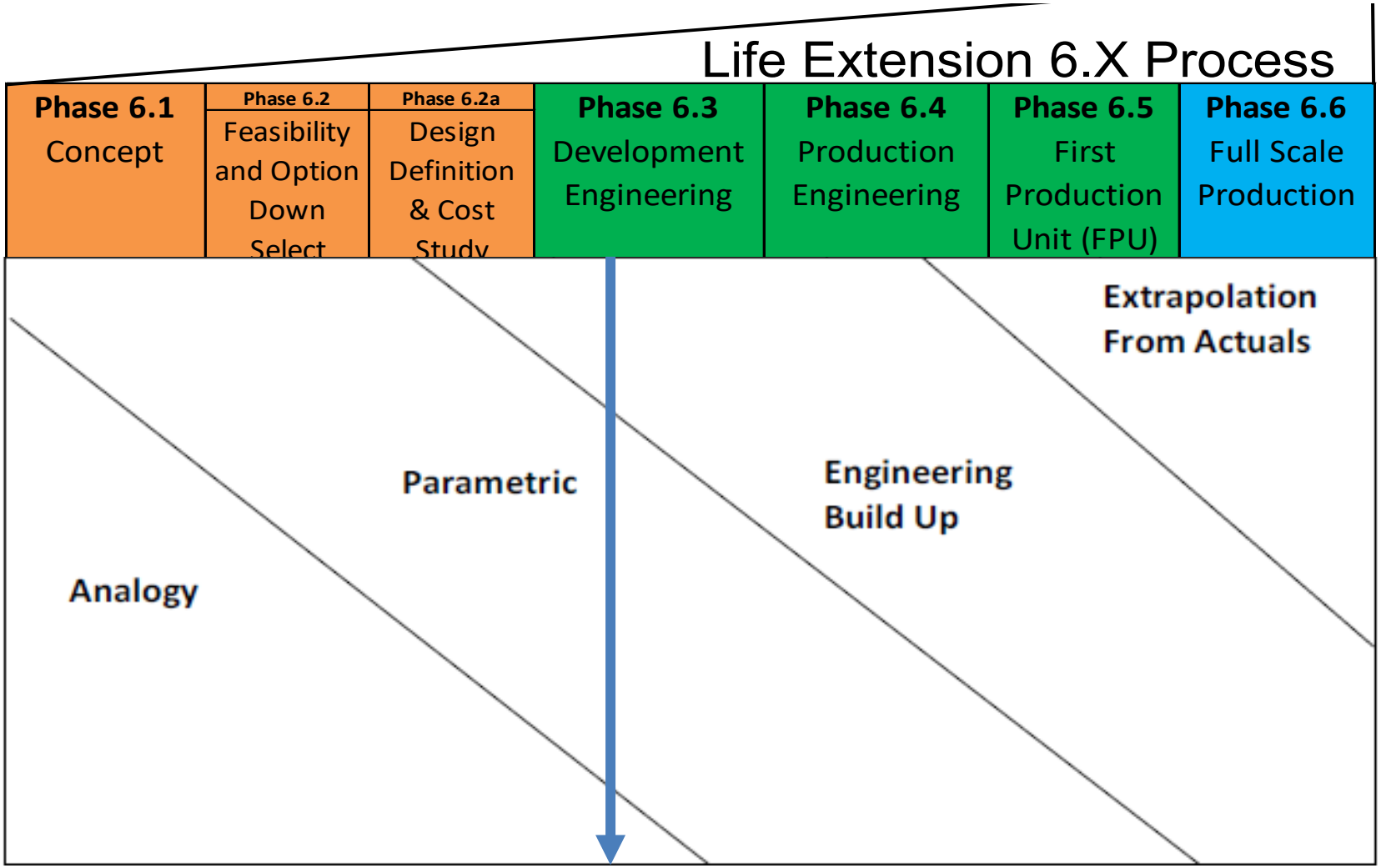
Phase 6.1	Phase 6.2	Phase 6.2a	Phase 6.3	Phase 6.4	Phase 6.5	Phase 6.6
Concept	Feasibility and Option Down Select	Design Definition & Cost Study	Development Engienering	Production Engineering	First Production Unit (FPU)	Full Scale Production

http://stormcloudcanadaproject.com/hondacivic1979.htm
https://nyautogiant.com/sale/honda-civic-sport-long-island-ny

Takeaways from NW Background

- No *new* nuclear weapon systems
- System complexity
- Cannot execute full-up nuclear weapons tests
- Unique materials
- Life expectancy

Cost Estimating Methodologies



Josserand, Terry. Nuclear Weapon Talk. Institute for Defense Analyses. August 2018. SAND Report, Sandia National Laboratories, Albuquerque, NM. SAND2018-6184.
GAO Cost Estimating Guide, GAO-09-3SP

Cost Estimating Methodologies

Life Extension 6.X Process

Phase 6.1 Concept	Phase 6.2 Feasibility and Option Down Select	Phase 6.2a Design Definition & Cost Study	Phase 6.3 Development Engineering	Phase 6.4 Production Engineering	Phase 6.5 First Production Unit (FPU)	Phase 6.6 Full Scale Production

Table 11: Three Cost Estimating Methods Compared

Method	Strength	Weakness	Application
Analogy	▪ Requires few data ▪ Based on actual data ▪ Reasonably quick ▪ Good audit trail	▪ Subjective adjustments ▪ Accuracy depends on similarity of items ▪ Difficult to assess effect of design change ▪ Blind to cost drivers	▪ When few data are available ▪ Rough-order-of-magnitude estimate ▪ Cross-check
Engineering build-up	▪ Easily audited ▪ Sensitive to labor rates ▪ Tracks vendor quotes ▪ Time honored	▪ Requires detailed design ▪ Slow and laborious ▪ Cumbersome	▪ Production estimating ▪ Software development ▪ Negotiations
Parametric	▪ Reasonably quick ▪ Encourages discipline ▪ Good audit trail ▪ Objective, little bias ▪ Cost driver visibility ▪ Incorporates real-world effects (funding, technical, risk)	▪ Lacks detail ▪ Model investment ▪ Cultural barriers ▪ Need to understand model's behavior	▪ Budgetary estimates ▪ Design-to-cost trade studies ▪ Cross-check ▪ Baseline estimate ▪ Cost goal allocations

Source: © 2003, MCR, LLC, "Cost Estimating: The Starting Point of EVM."

Josserand, Terry. Nuclear Weapon Talk. Institute for Defense Analyses. August 2018. SAND Report, Sandia National Laboratories, Albuquerque, NM. SAND2018-6184.
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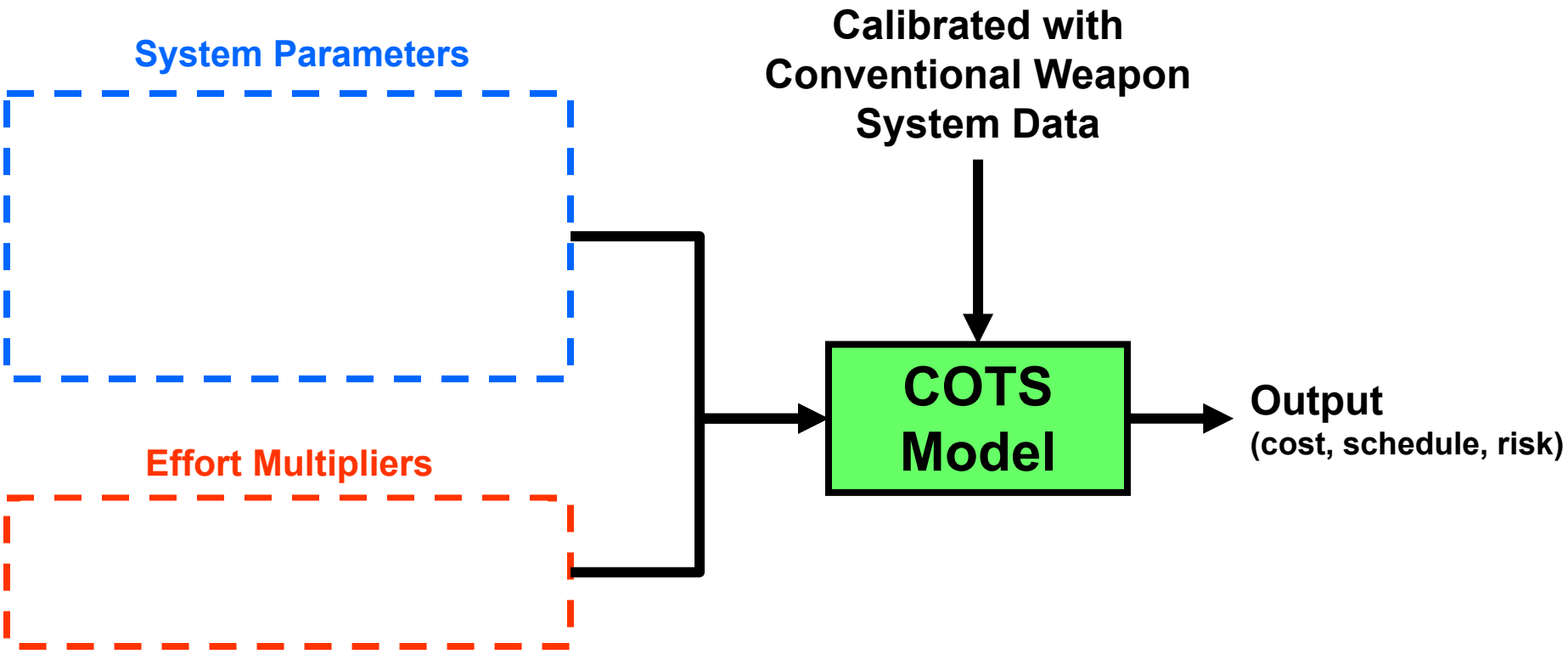
Model Concept



Types of Historic Nuclear Weapon Data

- Effort
  - Phase process
- Time
  - Fiscal years
- Cost
- Characteristics
  - Weight, interfaces, size, etc.
- Performance
  - Yield, speed, range, etc.
- Schedule
  - Time to develop, deploy, test, etc.
- Socio-political
  - Treaties, legislation, policy
- Reliability
  - Failures, issues, etc.
- Production
  - Numbers, processes, etc.
- System engineering complexity
  - Phase paradigm, age, etc.
- Staff
  - Experience, training, etc.
- Other data…

Josserand, Terry, Nuclear Weapon Talk, Institute for Defense Analyses. August 2018. SAND Report, Sandia National Laboratories, Albuquerque, NM. SAND2018-6134

GAO Cost Estimating Guide, GAO-09-3SP

Types of Historic Nuclear Weapon Data

- Effort
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- Character
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- Performa
  - Yield, sp
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  - Time to
- Socio-pol
  - Treaties

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Table 10: Basic Primary and Secondary Data Sources

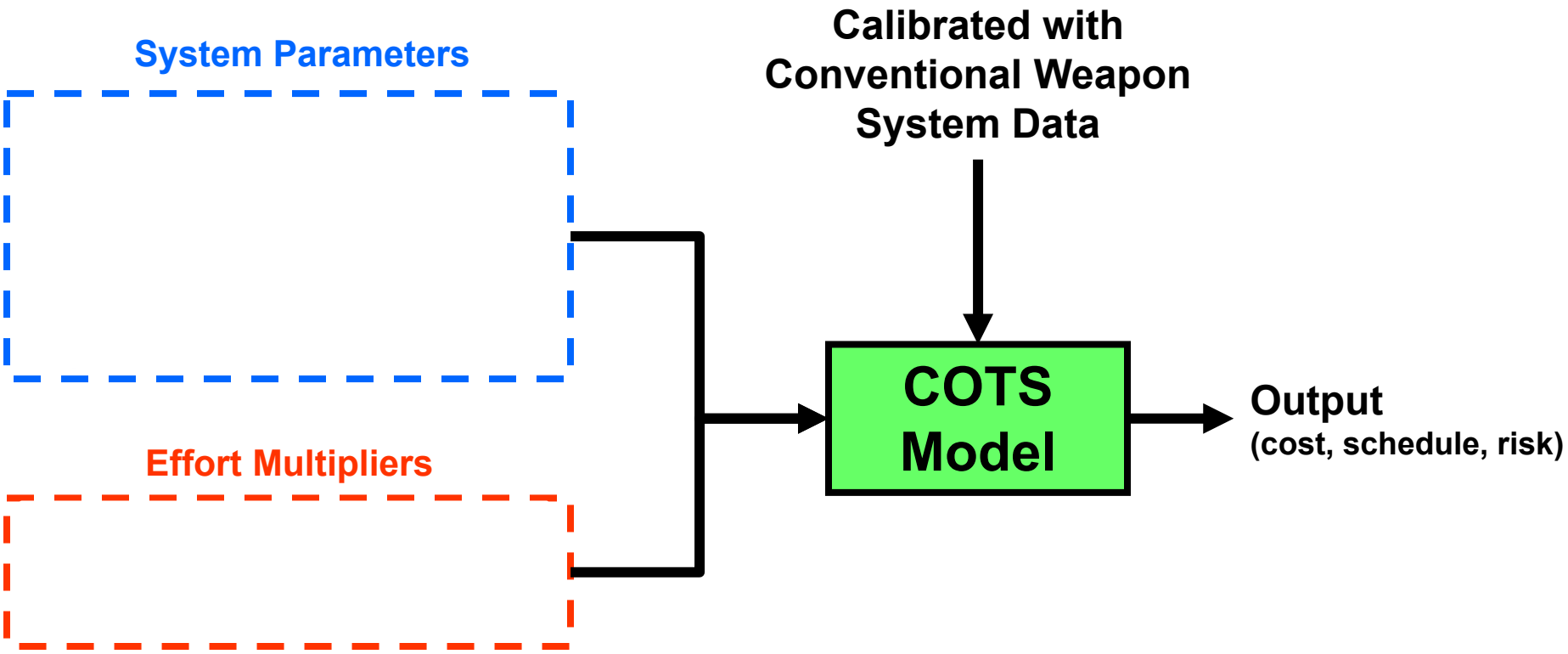
Data type	Primary	Secondary
Basic accounting records	x	
Data collection input forms	x	
Cost reports	x	x
Historical databases	x	x
Interviews	x	x
Program briefs	x	x
Subject matter experts	x	x
Technical databases	x	x
Other organizations	x	x
Contracts or contractor estimates		x
Cost proposals		x
Cost studies		x
Focus groups		x
Research papers		x
Surveys		x

Source: DOD and NASA.

Josserand, Terry, Nuclear Weapon Talk, Institute for Defense Analyses. August 2018. SAND Report, Sandia National Laboratories, Albuquerque, NM. SAND2018-6154

GAO Cost Estimating Guide, GAO-09-3SP

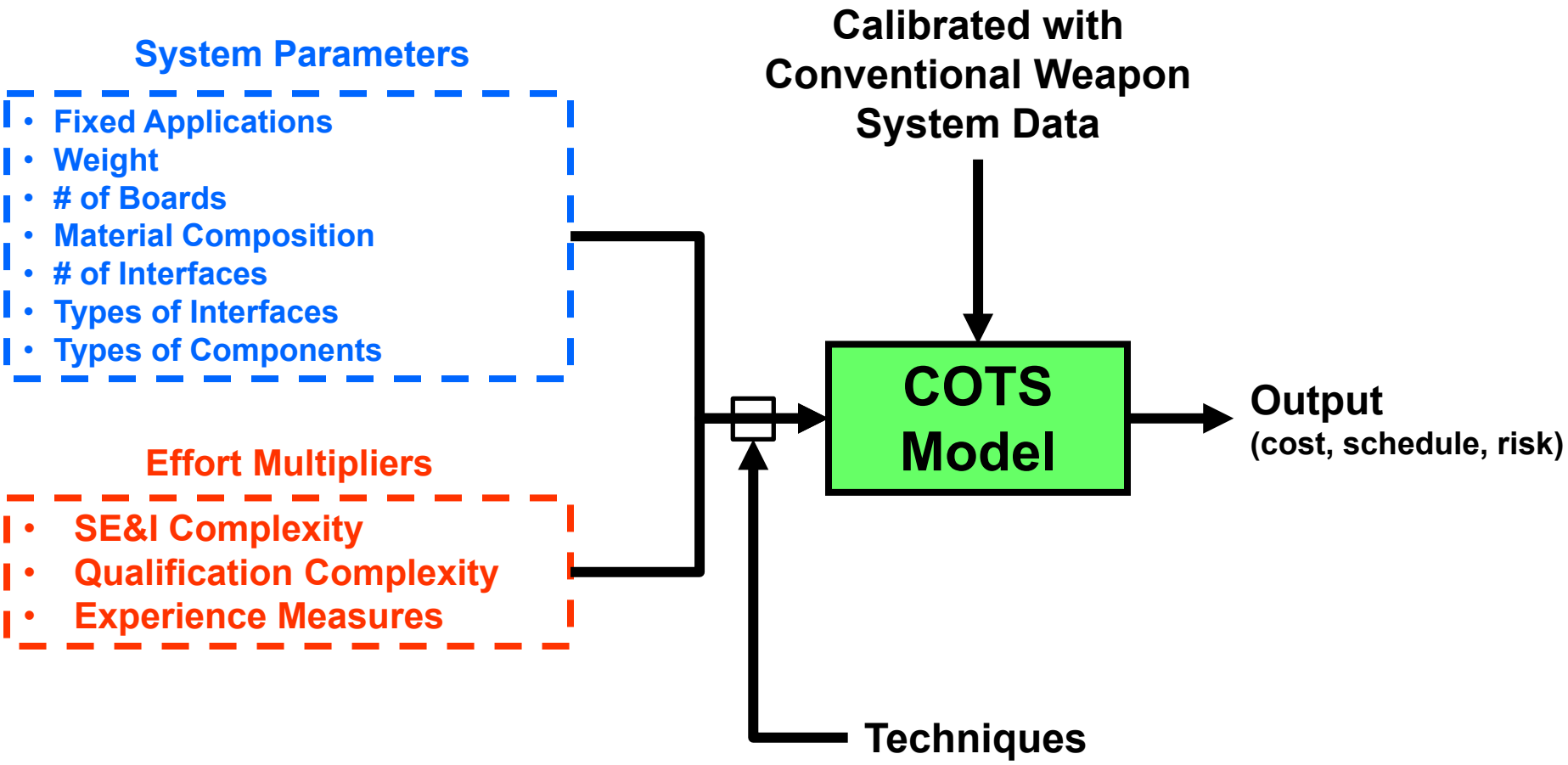
Model Concept



Two Approaches

- Top-Down
  - System, Subsystem, Major Components
    - Analogous technical data
    - Expert review
- Detailed Engineering Build-Up
  - System, Subsystem, Major Components, Subcomponents, Piece-Parts
    - Analogous technical data
    - Expert review

Model Concept

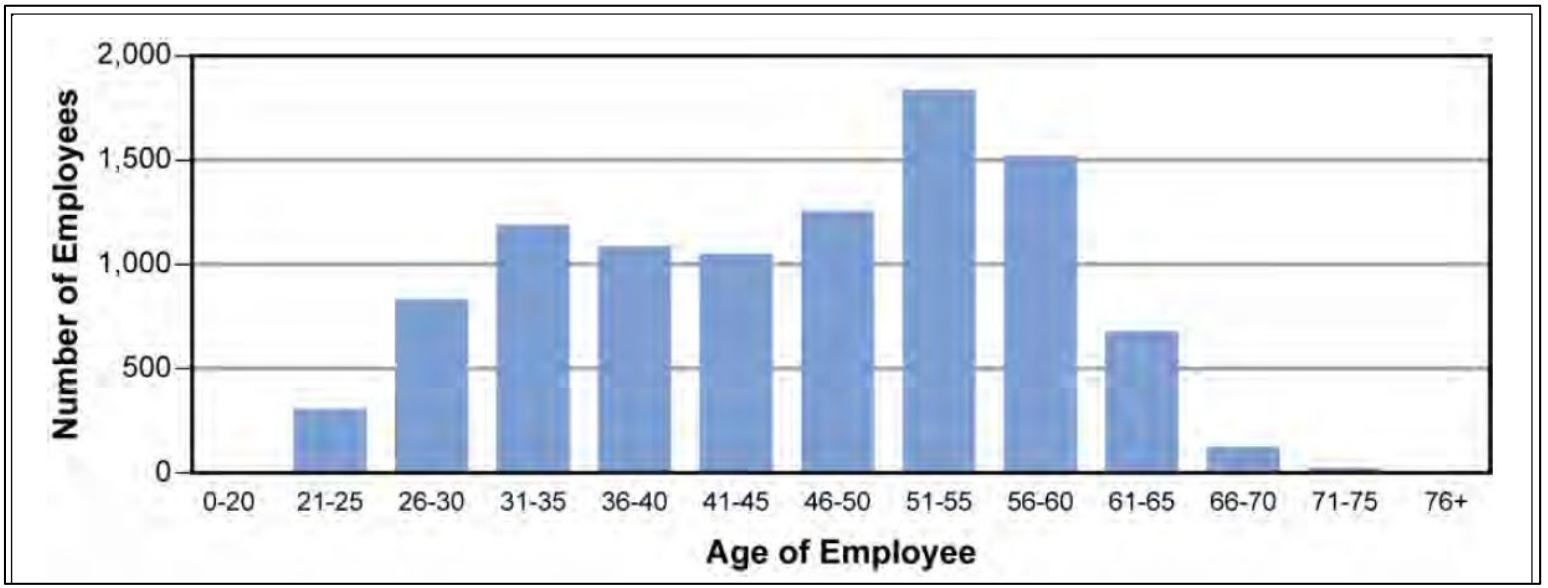


Techniques for System Parameters and Effort Multipliers

- Material Composition
  - Very High, exotic materials
- SE&I Complexity
  - Very High, system is composed of unique exotic materials and parts of varying ages
- Qualification
  - Very High, system requires qualification unique to conventional systems
- Experience Measures

Experience Measures

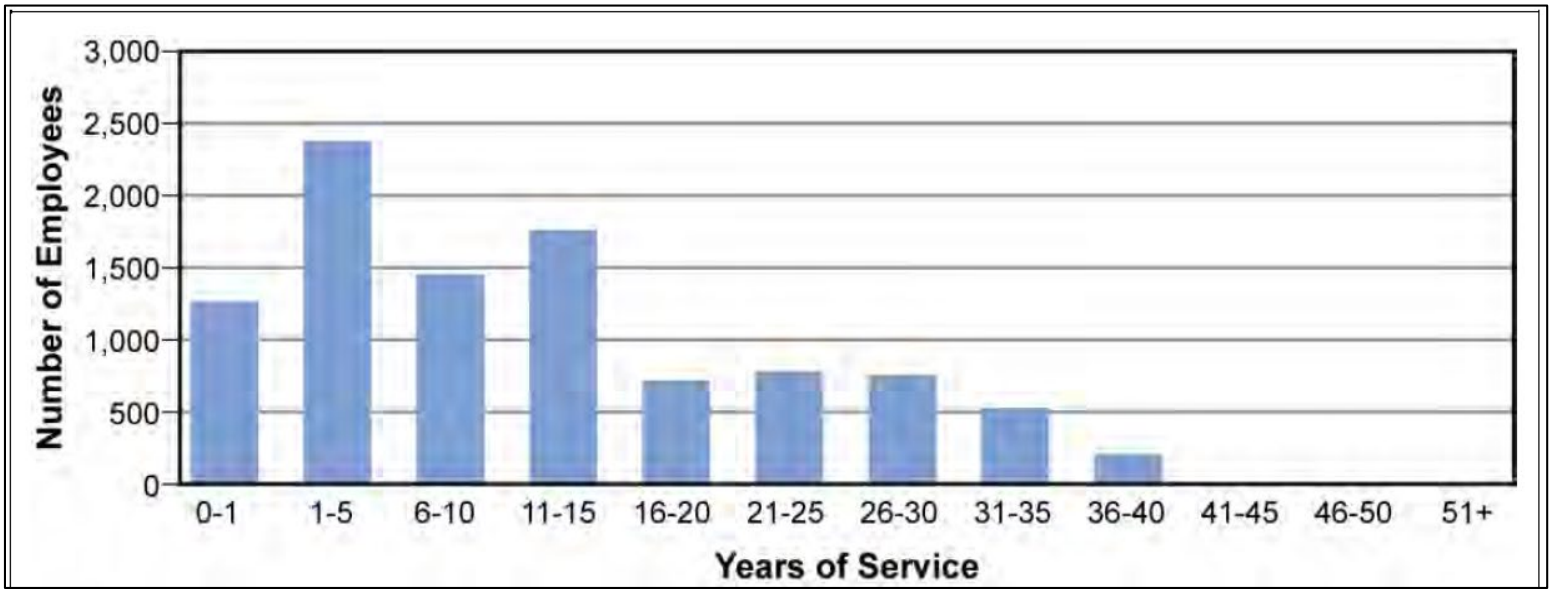
- Demographics
  - Bi-modal age distribution
  - 24% 56 and above
  - 64% between 31 and 55
  - 11% under 30
  - 21% eligible for retirement
  - 23% of engineers and 18% of scientists eligible for retirement
  - Experience shift



2016 NNSA Stockpile Stewardship and Management Plan

Experience Measures

- Demographics
  - 36% less than 5 years of service
  - 70% less than 16 years of service
  - Knowledge transfer



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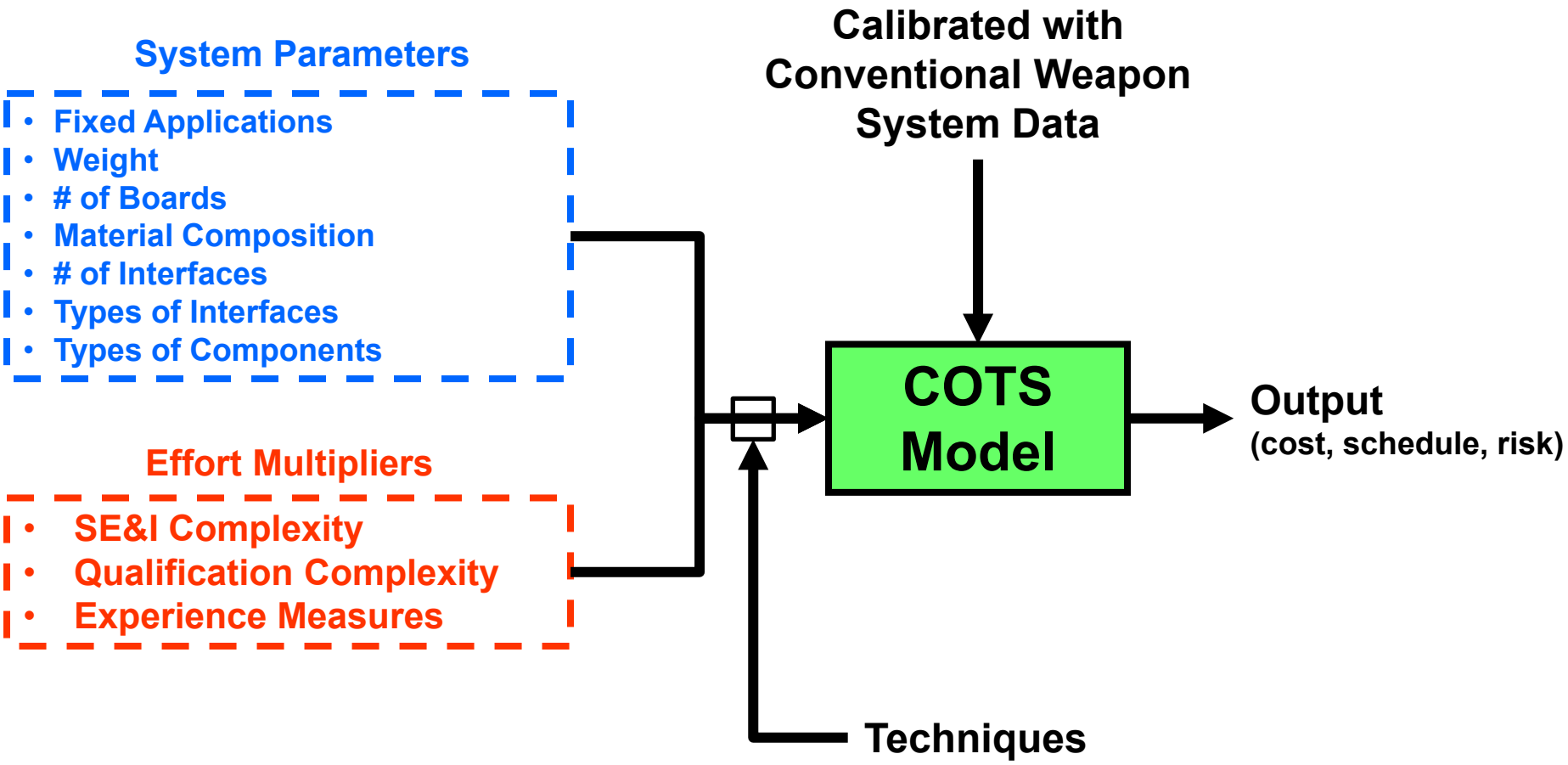
  - Low, *New* Weapon to Life Extension 6.X Process staff retention

Model Concept



Model Output Comparison

Top-Down System

Confidence Level	Dev Cost
10%	1.00
20%	1.00
30%	1.00
40%	1.00
50%	1.00
60%	1.00
70%	1.00
80%	1.00
90%	1.00
Mean	1.00
StdDev	1.00

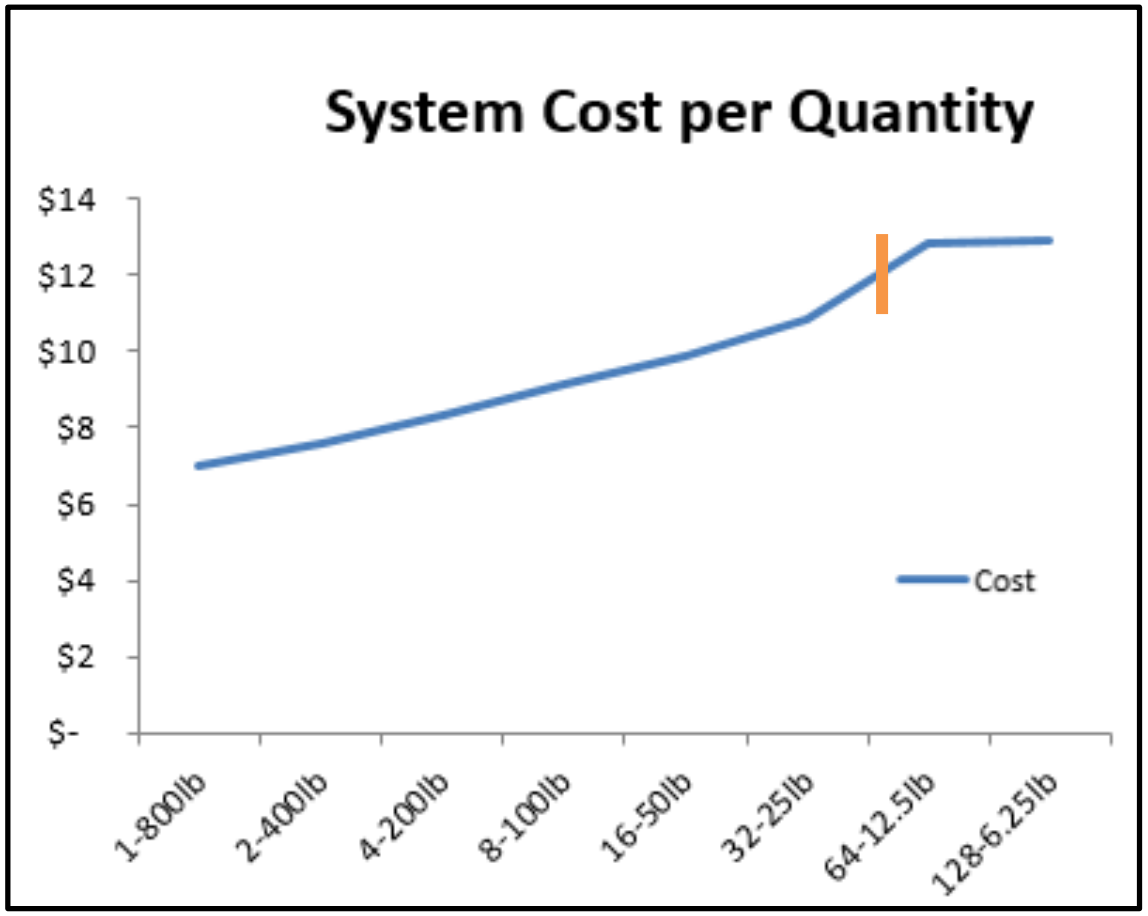
Engineering Build-Up System

Confidence Level	Dev Cost
10%	1.06
20%	1.09
30%	1.11
40%	1.13
50%	1.14
60%	1.15
70%	1.15
80%	1.16
90%	1.17
Mean	1.14
StdDev	1.21

Top-Down to Build-Up Delta
70% - 15%
80% - 16%
90% - 17%

Model Sensitivity of Part Quantity Detail

Desc	Cost	
1-800lb	$	7
2-400lb	$	8
4-200lb	$	8
8-100lb	$	9
16-50lb	$	10
32-25lb	$	11
64-12.5lb	$	13
128-6.25lb	$	13



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Discussion
Questions/Suggestions?

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