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## State Machine Model of Information Processing in an Operations Center

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## Outline

- State Machine Versus Classical Views
- State Machine Versus Queuing Theory
- Example Job Thread
- State Machine EFFBDs
- Simulation Process
- Business Rules
- Sample Results Analysis
- Future Work: SMOFN
- Design & Limits (aka Disclaimer)
- Conclusions



## State Machine Versus Classical Views

- Classical diagrams display single-threaded, single-instance temporal domains (i.e. along timeline)
- State machine is multi-threaded, multi-instance of temporal domain (i.e. orthogonal to timeline)
- SM is really an ‘engine’ for processing scenarios
  - Logic for workflow, resources, and queues captured as rule sets within tasking process
  - Jobs allocated to operators and tracked continuously
- Caution: SM Logic is not as visible to users as behaviour models

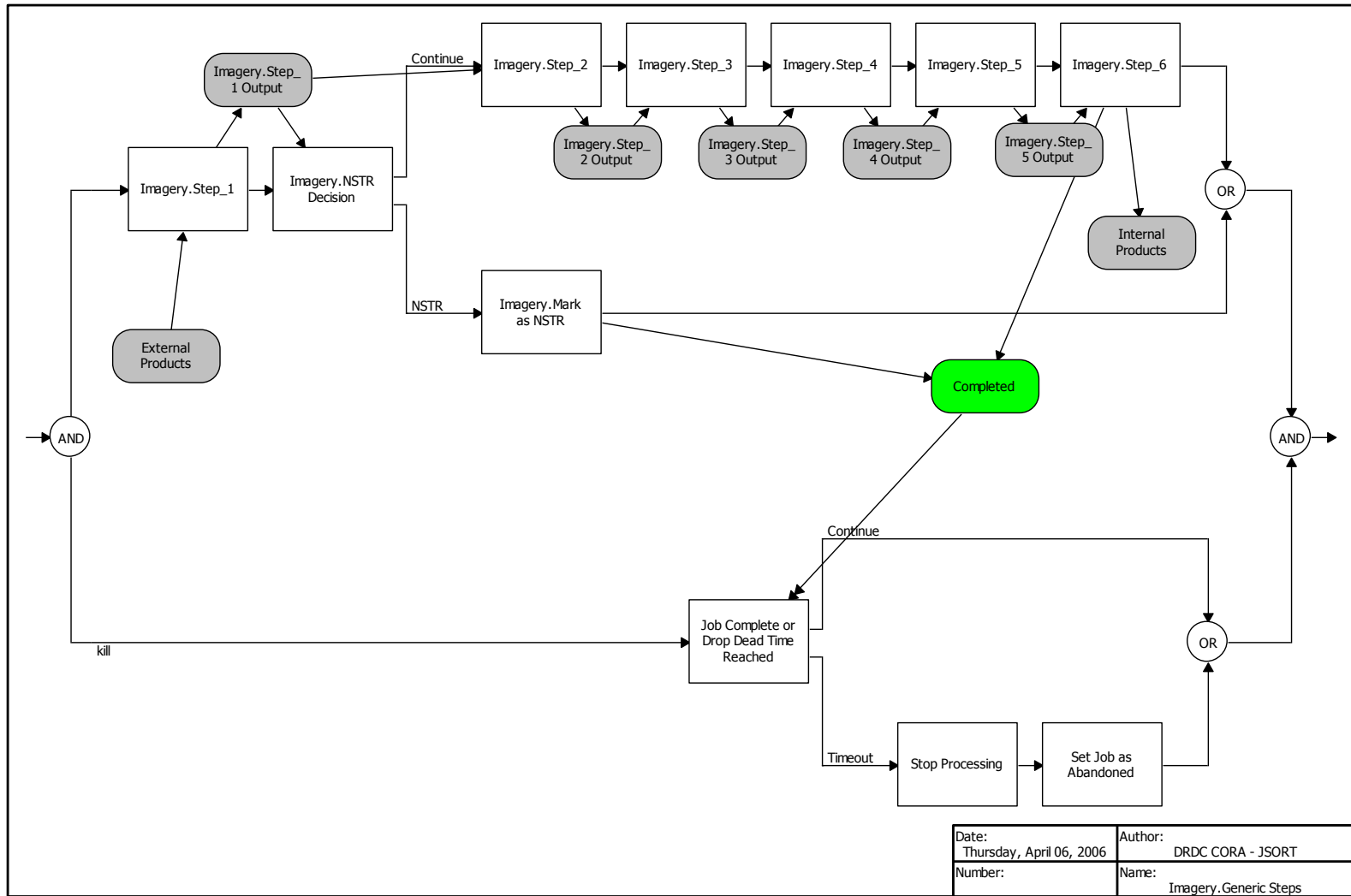


## State Machine Versus Queuing Theory

- State machine models real-world situations and details without many of the simplifying assumptions needed by queuing theory
- Simulates the system by tracking activity at any desired level of detail



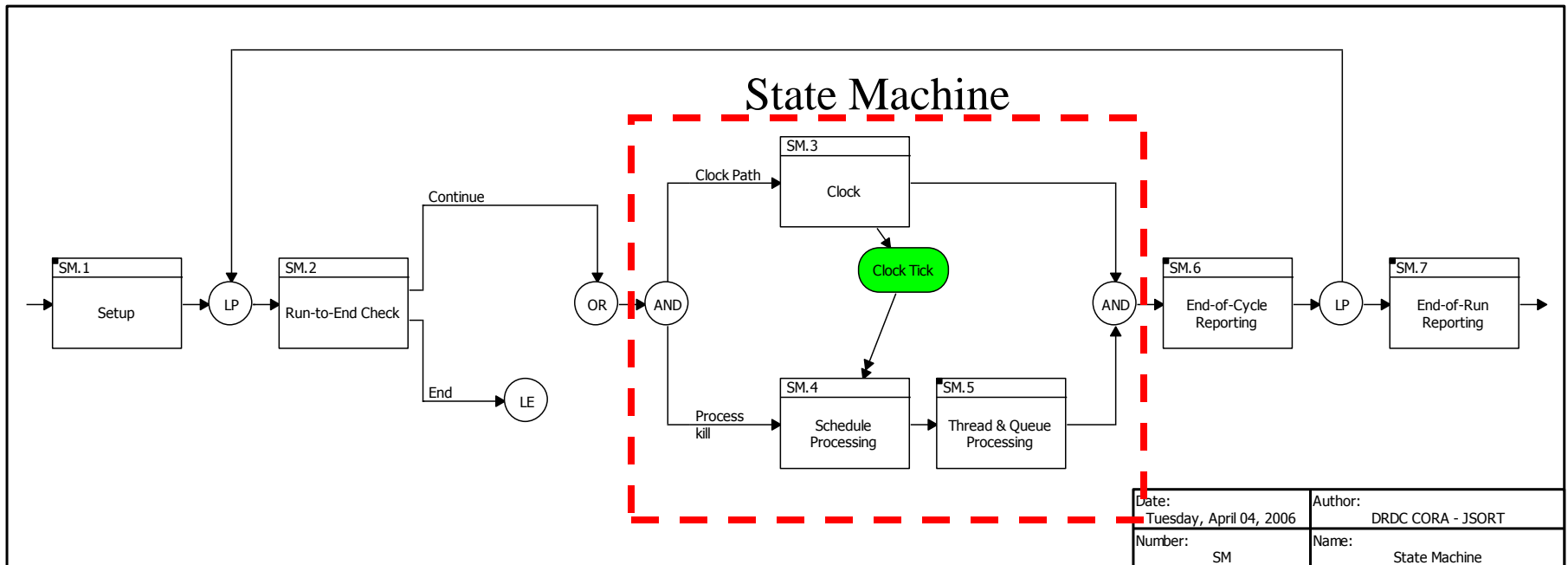
# Example Job Thread



Date: Thursday, April 06, 2006	Author: DRDC CORA - JSORT
Number:	Name: Imagery.Generic Steps



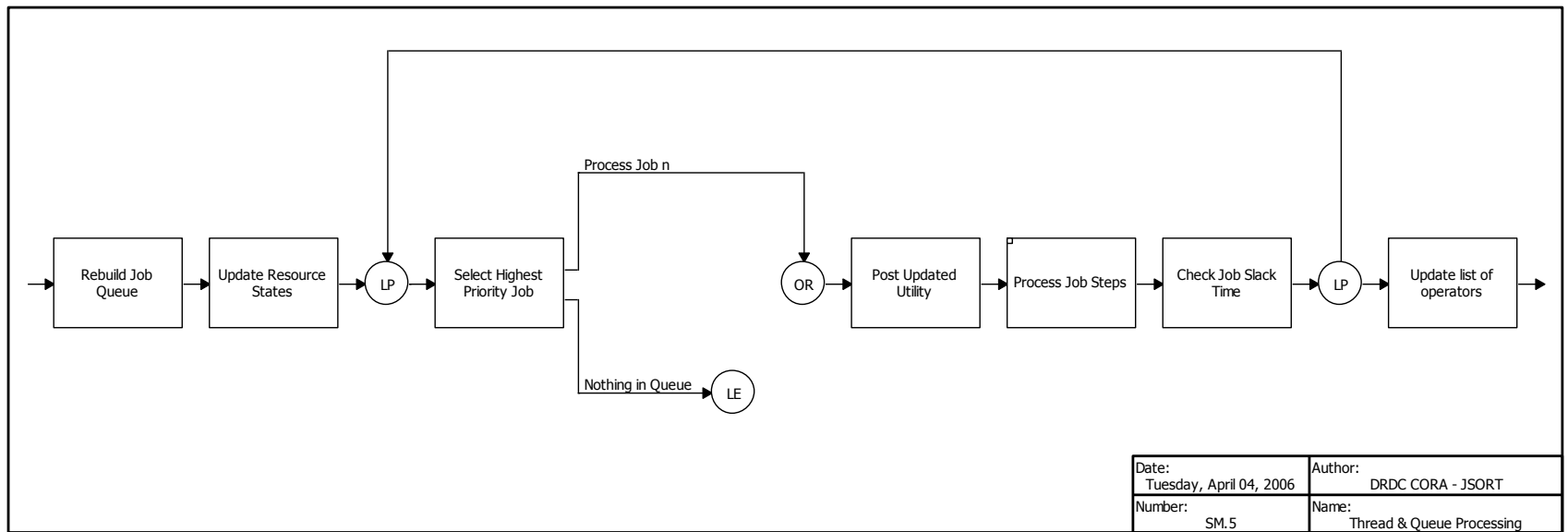
# State Machine Top-Level Model







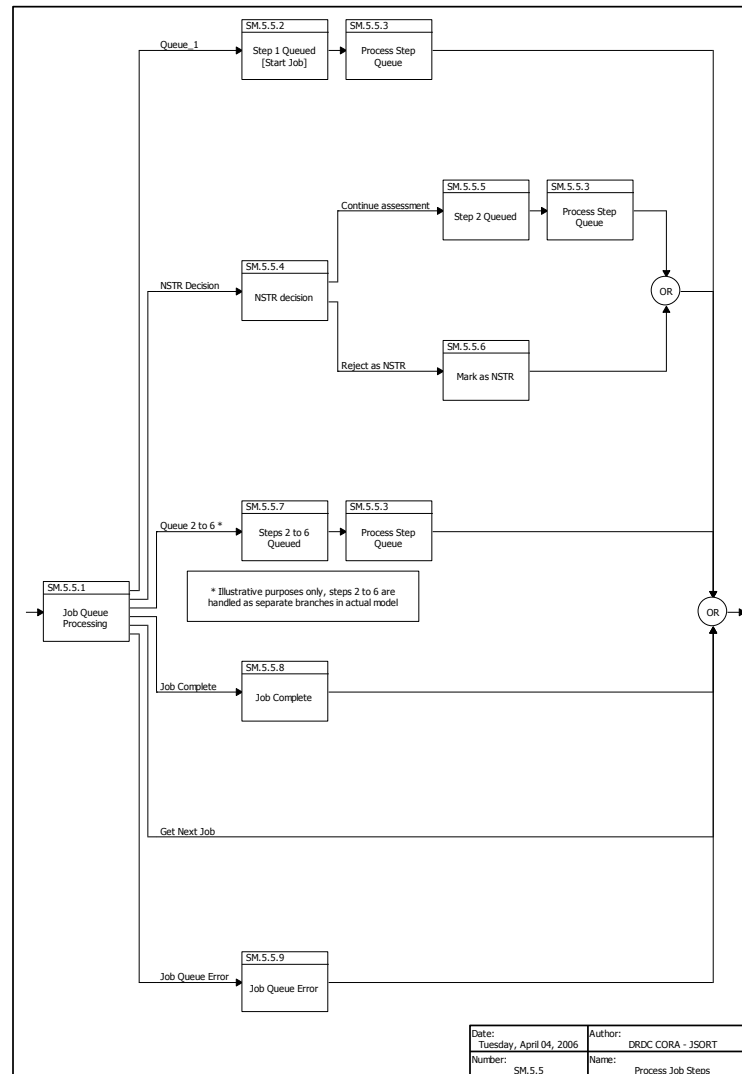
# Thread and Queue Processing





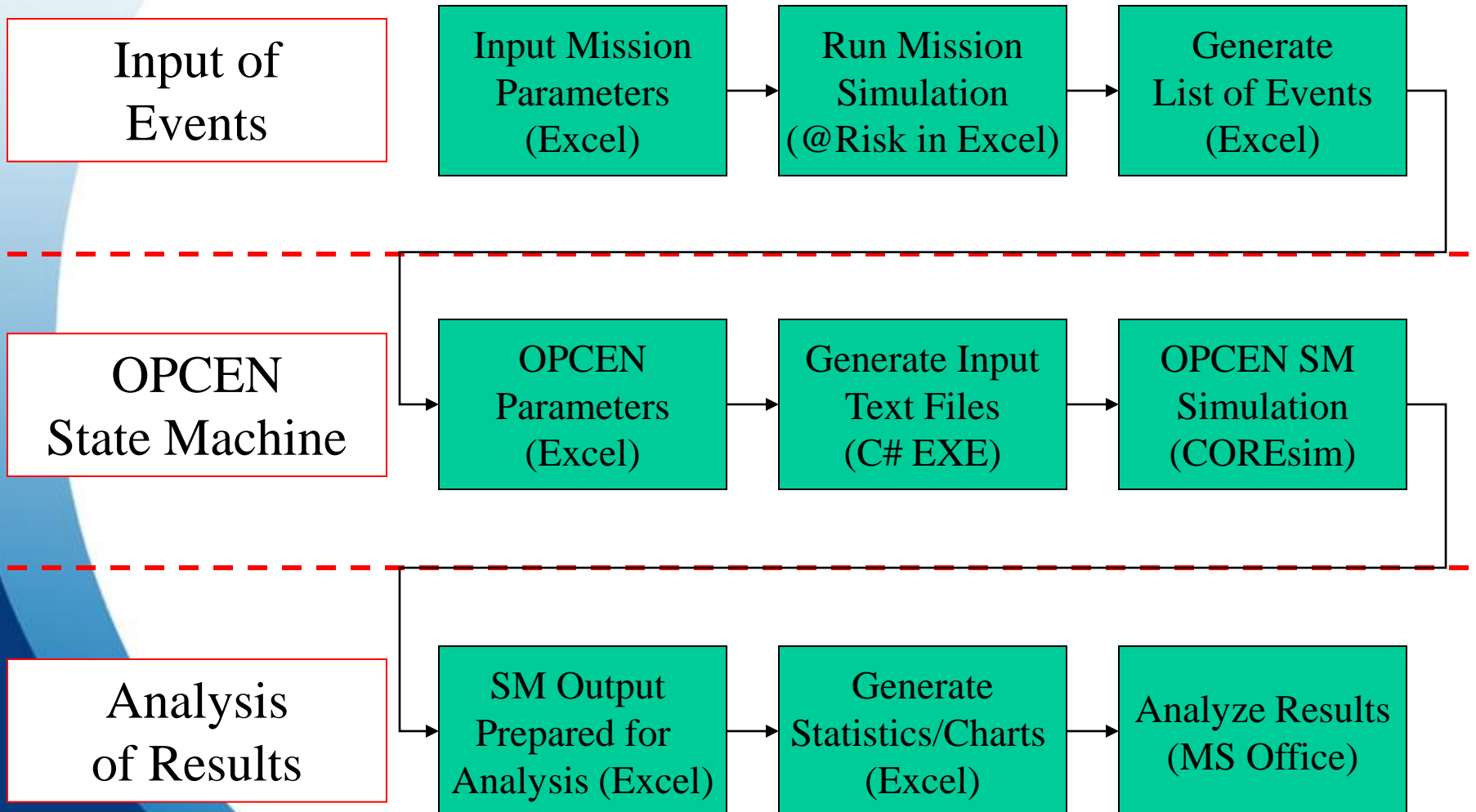


# Process Job Steps





# SM Simulation Process (March 2006)





# Sample Data Entry

	A	B	C	D	E
1	Job	Arrival Time	EventType	Priority	Deadline
2	1	00:00:01	COP	400	0:00:00
3	2	00:00:01	Imagery	200	0:00:00
4	3	00:00:01	SITREP	300	0:00:00
5	4	00:00:03	Assessment	200	0:00:00
6	5	00:00:03	Imagery	150	0:00:00
7	6	00:00:05	Imagery	198	0:00:00
8	7	00:00:06	COP	400	0:00:00
9	8	00:00:07	Imagery	201	0:00:37
10	9	00:00:08	SITREP	100	0:00:37
11	10	00:00:09	Imagery	200	0:00:37
12	11	00:00:10	SITREP	100	0:00:00
13	12	00:00:11	Imagery	100	0:00:00
14	13	00:00:12	COP	400	0:00:00
15	14	00:00:13	Imagery	200	0:00:00
16	15	00:00:14	SITREP	300	0:00:00
17	16	00:00:15	Imagery	200	0:00:00
18	17	00:00:16	Assessment	100	0:00:00
19	18	00:00:17	Imagery	200	0:00:57
20	19	00:00:18	COP	400	0:00:00

	A	B	C	D	E	F	G	H	I	J	K	L
1	Thread Name	Priority Within Thread	Priority Across Threads	Fraction NSTR	Slack Time (initial)	Total thread time	Step_1	Step_2	Step_3	Step_4	Step_5	Step_6
2	Imagery	Normal	200	50%	30	42	10	1	15	10	5	1
3	Imagery	High	100	20%	20	37	10	1	10	10	5	1
4	COP	Normal	400	10%	15	7	1	1	2	0	2	1
5	SITREP	Normal	300	5%	30	28	5	1	5	15	1	1
6	SITREP	High	100	5%	15	23	5	1	5	10	1	1
7	Assessment	Normal	200	33%	15	38	10	1	1	20	5	1
8	Assessment	High	100	10%	5	14	1	1	1	5	5	1



## Business Rules Implemented (1 of 2)

- Event list triggers jobs that can be standard types or customized
- Ties between equal priorities broken by:
  - Least slack time
  - Most utility / time
- Operators allowed to have multiple skills:
  - Jobs allocated to primary skill, then others
  - Available operator whose (quality of work) X (speed) is highest is preferentially assigned to jobs
  - Generic jobs to idle operators in mandated order



## Business Rules Implemented (2 of 2)

- Interruptions: Operator can set aside Job A to work on Job B if
  - Job B higher priority; or
  - Nobody else available for Job B, but available to take over Job A
- Utility function\*
  - User-defined triangular distribution within each thread step
  - Value from previous step is used to revise distribution bounds (utility cannot go down)
- Switchboard to turn on and off business rules/options

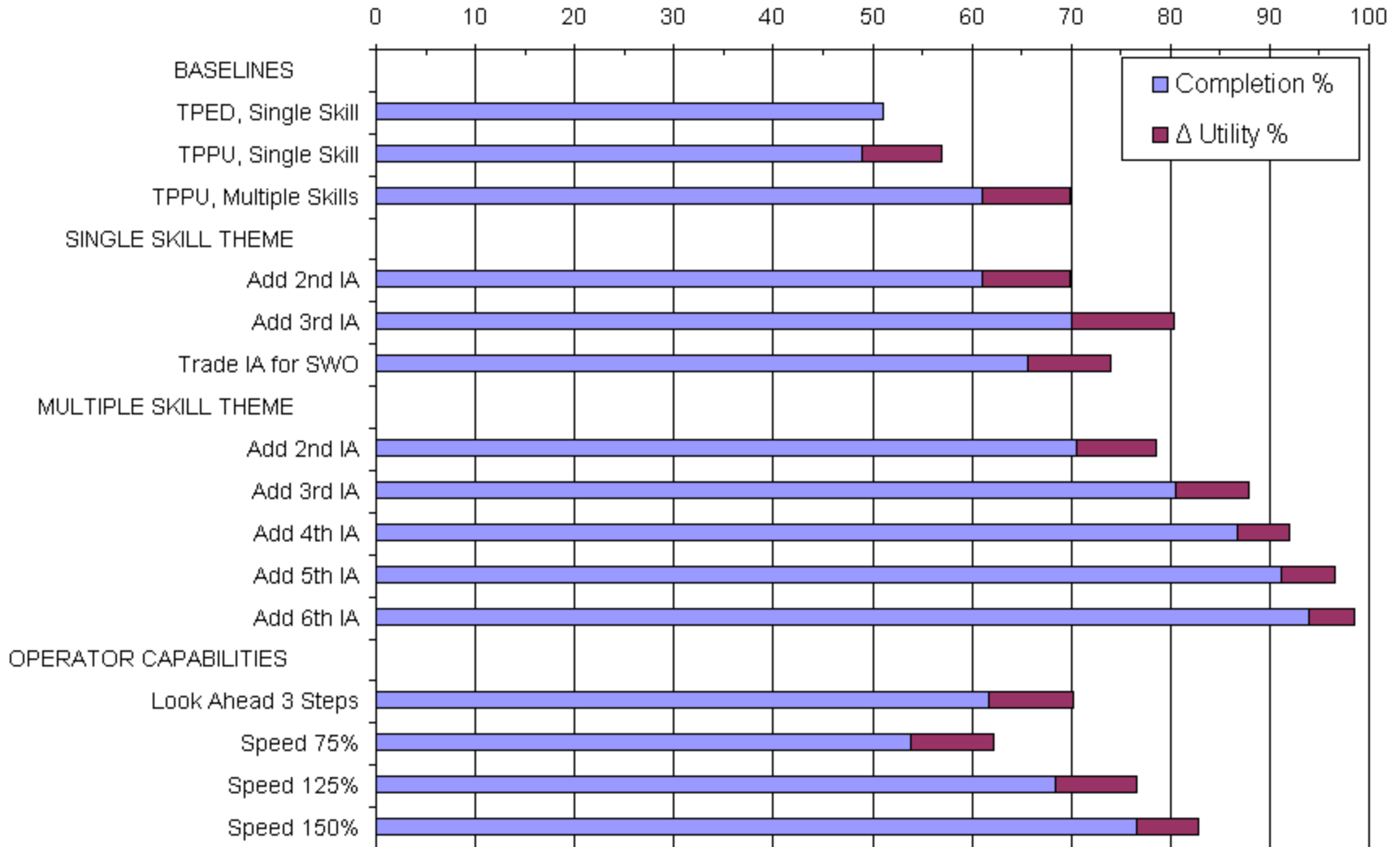
\*See presentation by Sylvain Gauthier tomorrow, 1230



# Comparison of State Machine Planning Assumptions – March 2006

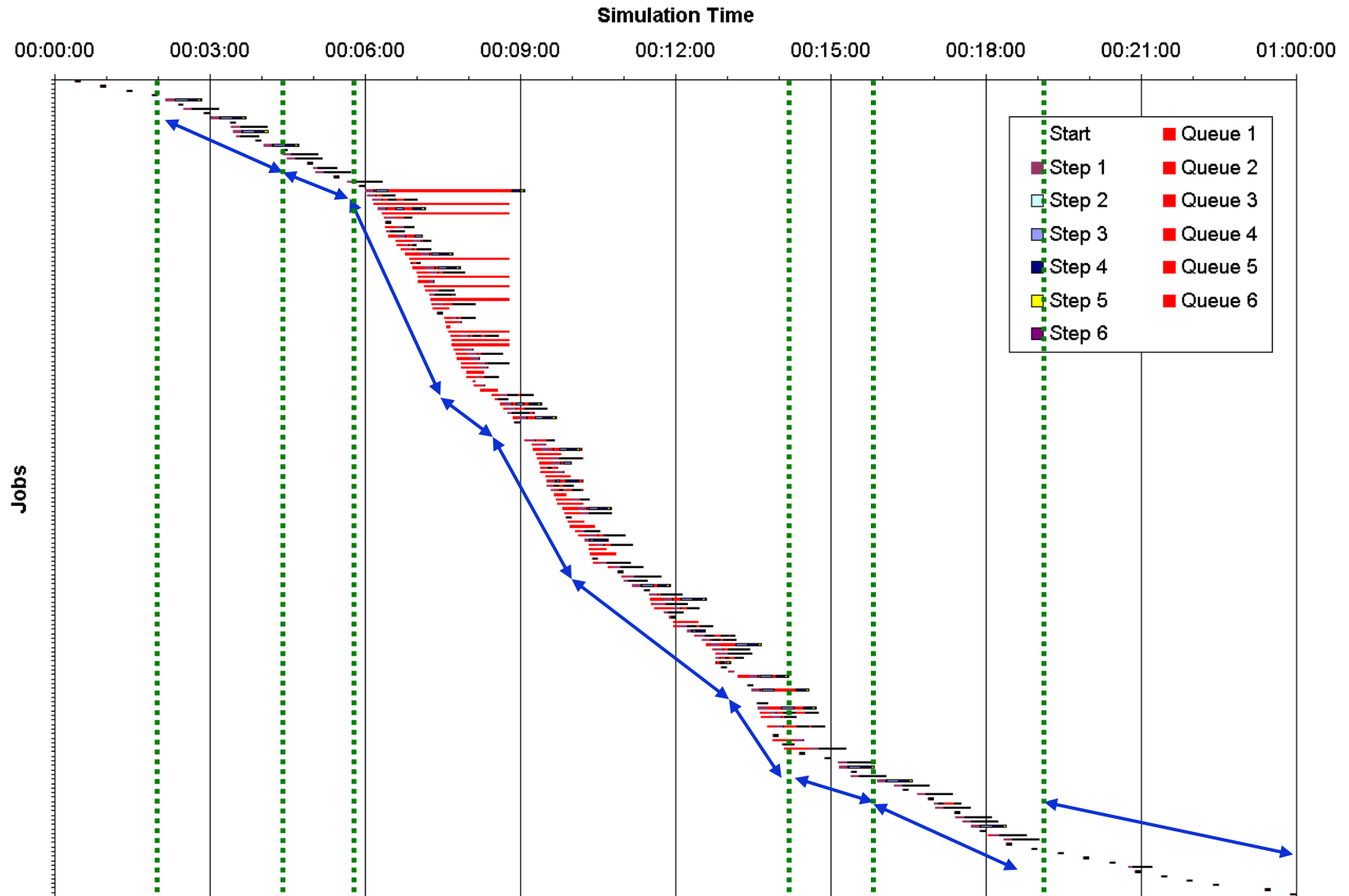
Changes to Baseline

Percentage





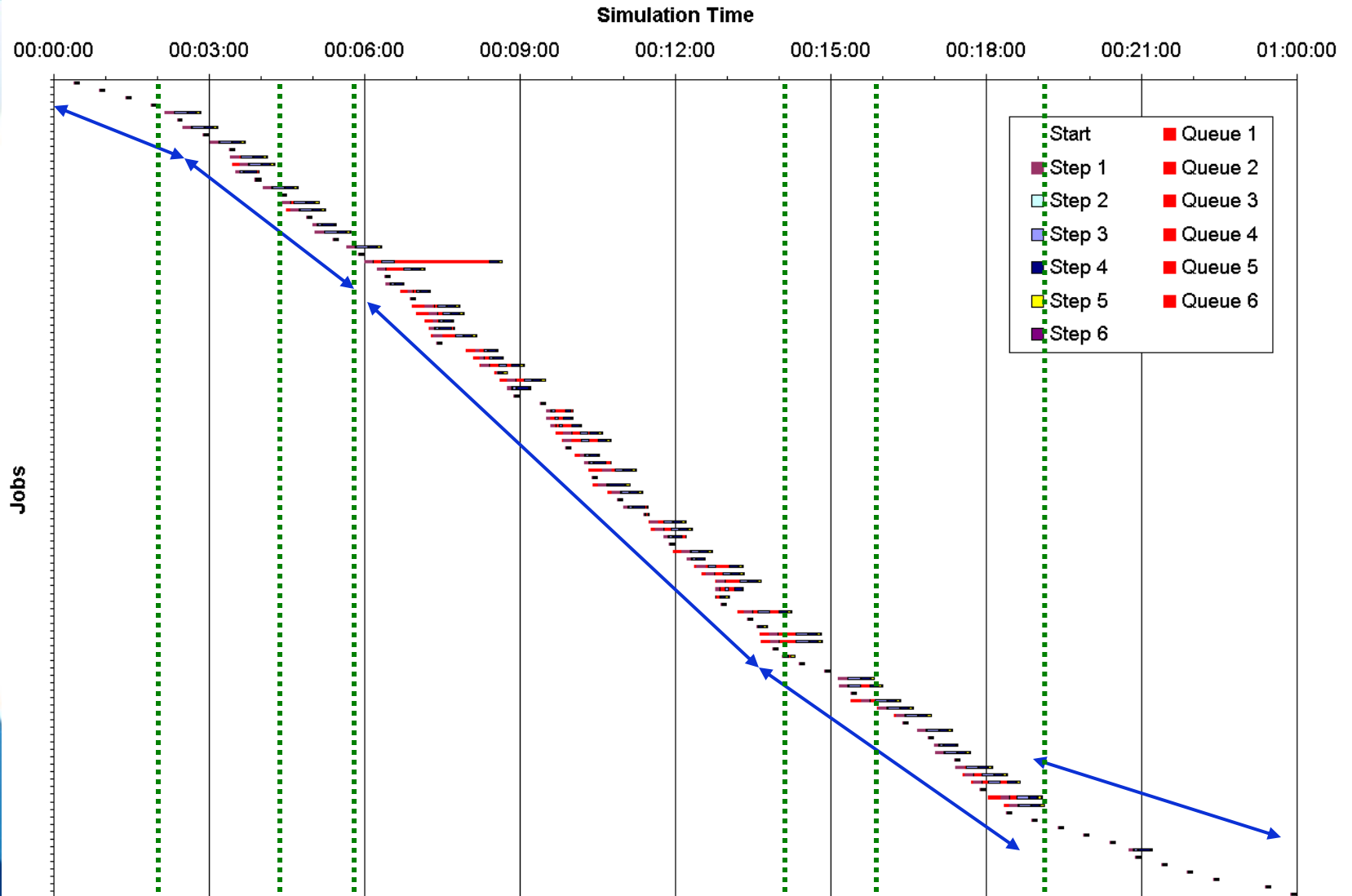
# Timeline of All Jobs (Multiple Skills) - March 2006







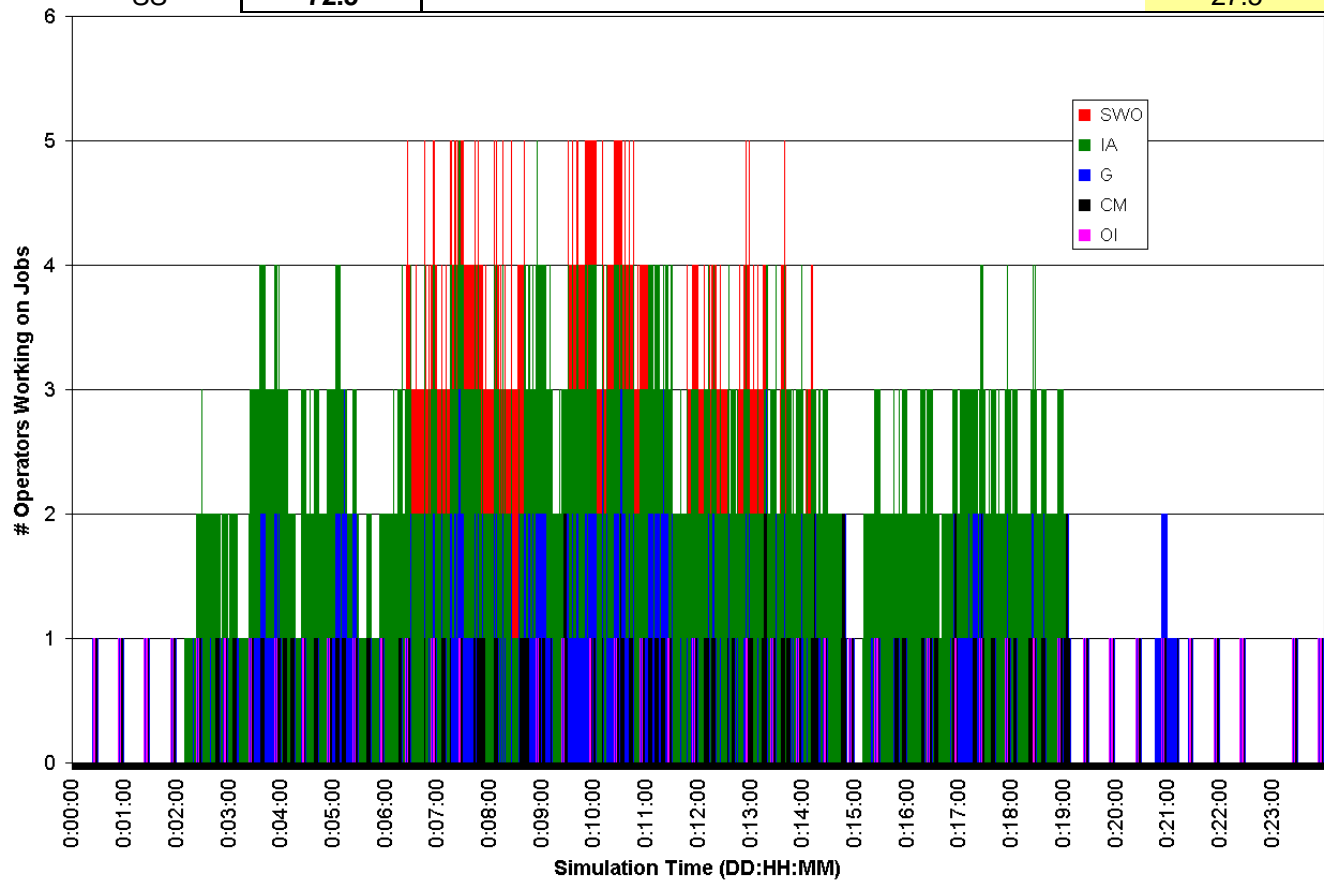
# Timeline of Completed Jobs (Multiple Skills) - March 2006





# Personnel Utilization – March 2006 (5 Operators With Multiple Skills)

Skill Used >>	SA	SWO	IA	OI	CM	G
Average	58.0	4.5	24.2	1.8	4.7	6.7
SWO	77.8	21.5		0.6		0.1
IA	33.7	1.0	65.3			
OI	70.8			8.4	15.0	5.8
CM	35.4		55.9		8.7	
SS	72.5					27.5





# Future Work: State Machine of Federated Nodes (SMOFN) Model

- CORA funded to develop capability engineering tools
- Extends SM model from single OPCEN to multiple locations
  - Focus is on utility life-cycle and flow of
  - Repository node manages and shares products
- Project covers five phases (Jan 06 to Mar 07)
  - Phase 1 is completed, other 4 are funded options:
    1. Explored issues with simple example using nominal data (Concluded SMOFN feasible and ready to Phase 2)
    - 2&3. Develop and adapt use-cases as realistic versions (Aspects of CF Command Structure and MSOC)
    - 4&5. Refine analysis tools & allow further use-cases (TBD)



## Design & Limits

- The SM model is designed to:
  - Calculate how much work can be done on a set of jobs
  - Provide a basis to compare a range of business rules
- The SM model can account for job status:
  - Who is assigned
  - Where they reside as they flow through the thread
  - How business rules interact to direct their flow
- The SM model is NOT intended to explain:
  - Why a particular workflow pattern was chosen
  - How an operator actually accomplishes the work within each step



## Conclusions

- Classical behavioural models of concurrent, interruptible processes are not scalable
- Each time step, state machine goes through list of all processes, addressing them in order of priority
  - Length of list limited only by computing power, not model
- State machine is data-driven, allowing user to specify particulars related to general processes, specific instances, OPCEN staff
- Simulation results allow comparison between datasets

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