DEFENCE R&D DÉFENSE

Practical Organizational Efficiency and Effectiveness Modeling

Presented at 29 ISMOR
28 August 2012

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POE²M - Outline

- Context
- Efficiency
- Effectiveness
- Conclusions
- References

POE²M – Context

- Climate of austerity
  - Strategic Review (2010) – all GoC
    - 5% targeted (programmatic) reductions
  - Deficit Reduction Action Plan (2011) – all GoC
    - 5 – 10% spending reductions
  - CF Transformation 2011 – DND / CF only
    - Internal reallocation of defence resources
  - Administrative Services Review (2011) – all GoC
    - Review of administrative services

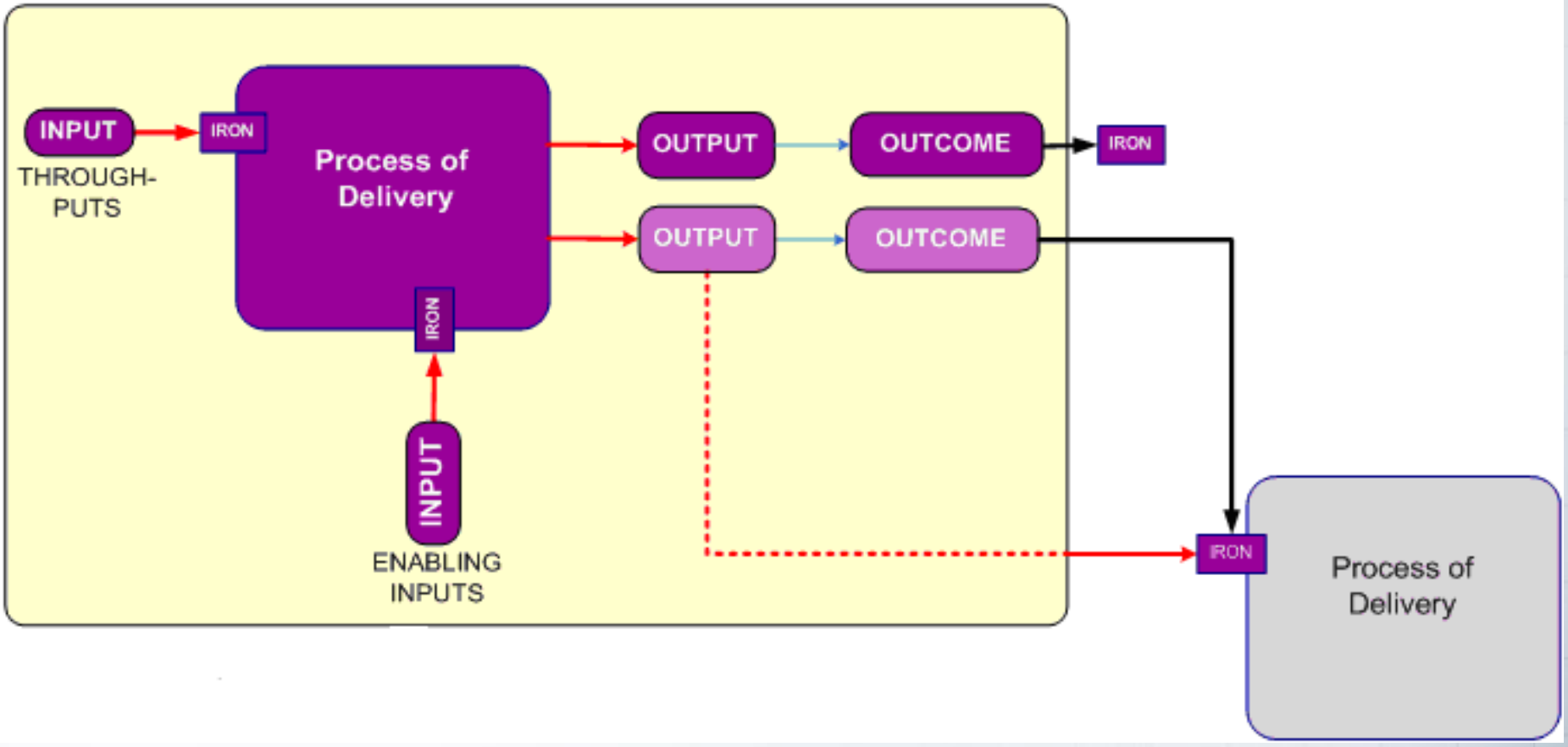
POE²M – Context

- Expectations of Efficiency / Effectiveness
  - GoC
    - Shared Services Canada
      - Centralized network administration for many large departments in GoC
    - Other common services may be moved to this service-delivery model
  - DND
    - DG Lean
      - Six sigma, BPR, Hammer,

POE²M – Context

- The “Logic Model”
  - Core of “components” in 2010 Strategic Review work
  - Forms the basis for our current efforts
  - Rooted in theoretical work in program evaluation and business process management / renewal

POE²M – Context

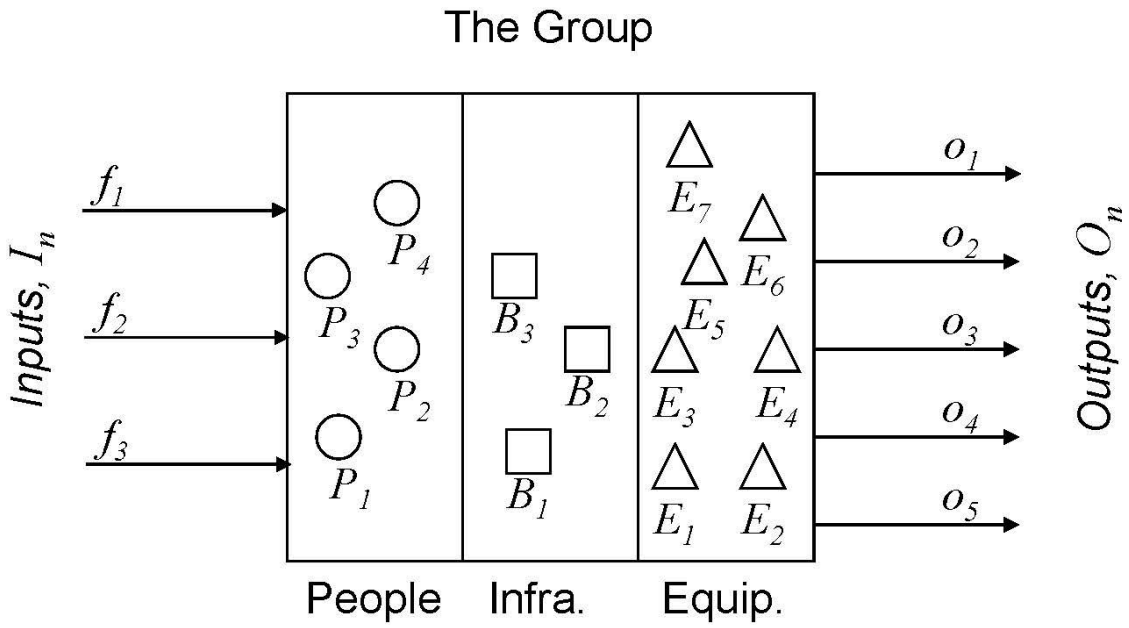


2010 Strategic Review Logic Model

POE^{2}M – Context

- The “Group” (unit)
  - Basis for analysis in POE^{2}M work
  - Self-similar, additive, can represent any level of organization

POE²M – Context



f_n = n^{th} input rate
o_n = n^{th} output rate
P_n = n^{th} person in group
B_n = n^{th} infrastructure of group
E_n = n^{th} equipment in group

POE²M – Efficiency Modeling

- What is efficiency?
- TBS (Treasury Board of Canada Secretariat) defines efficiency as:
  - The production of a greater quantity of outputs with the same level of inputs; OR
  - The production of the same quantity of outputs with a decreased level of inputs
- We feel these are actually addressing changes in efficiency, rather than efficiency itself
- Mathematically, we choose to define our efficiency measure as:

$$\eta = \frac{\text{output}}{\text{resources}}$$

POE²M – Efficiency Modeling

- There are any number of ways to estimate efficiency
- Many have been tried, to varying degrees of success
- Popular approaches have included:
  - Econometric models
  - Log-linear models
  - Elasticity / substitutability models
  - Monte Carlo simulation

- We decided to approach the problem from a first-order linear sums perspective

POE²M – Efficiency Modeling

- The general case model we developed either incorporates, or can incorporate, most common activity inputs (PRICIE, TEPID OIL, etc.)
- The general form is simply a complex linear sum:

$$\eta = \frac{\sum_{j=1}^{N_0} S_i L_{ij} \rho_{ij}^{*} + \sum \left(\beta_{1k} + \beta_{2k} \right) + \varepsilon_1 + \varepsilon_2 + \sum_{i=1}^{N_P} e_i^0 L_i}{\sum_{i=1}^{N_P} S_i + \sum_{k=1}^{N_B} M_k \frac{\alpha_k}{A_k} + \sum_{i}^{N_P} e_i^0 + \sum_{j=1}^{N_E} e_j}$$

POE²M – Efficiency Modeling

- Individual level efficiency approximation

$$\eta = \frac{\sum_{j=1}^{N_0} S_i L_{ij} \rho_{ij}^{*} + \sum \left(\beta_{1k} + \beta_{2k} \right) + \varepsilon_1 + \varepsilon_2 + \sum_{i=1}^{N_P} e_i^0 L_i}{\sum_{i=1}^{N_P} S_i + \sum_{k=1}^{N_B} M_k \frac{\alpha_k}{A_k} + \sum_{i}^{N_P} e_i^0 + \sum_{j=1}^{N_E} e_j}$$

POE²M – Efficiency Modeling

- Group level efficiency approximation

$$\eta = \frac{\frac{C_P}{N_P}\sum_{j=1}^{N_0}\frac{o_j}{\bar{p}_j} + \sum\left(\beta_{1k} + \beta_{2k}\right) + \varepsilon_1 + \varepsilon_2 + \bar{e}^{0}\sum_{j=1}^{N_O} N_{p_j}}{C_p + \sum_{k=1}^{N_B} M_k \frac{\alpha_k}{A_k} + \bar{e}^{0} N_P + \sum_{j=1}^{N_E} e_j}$$

POE^{2}M – Efficiency Modeling

- The inputs to the model are simple tables that are used as the basis for distributional sampling in the Monte Carlo simulations

- These tables are derived from the literature, best practices or can be simple estimates for a first-order approximation until better data are available

- For the table presented (mapping each person's PY to the outputs they are to deliver), the rows sum to unity, representing an entire PY of effort

PY Apportionment

3 person unit, producing 4 outputs

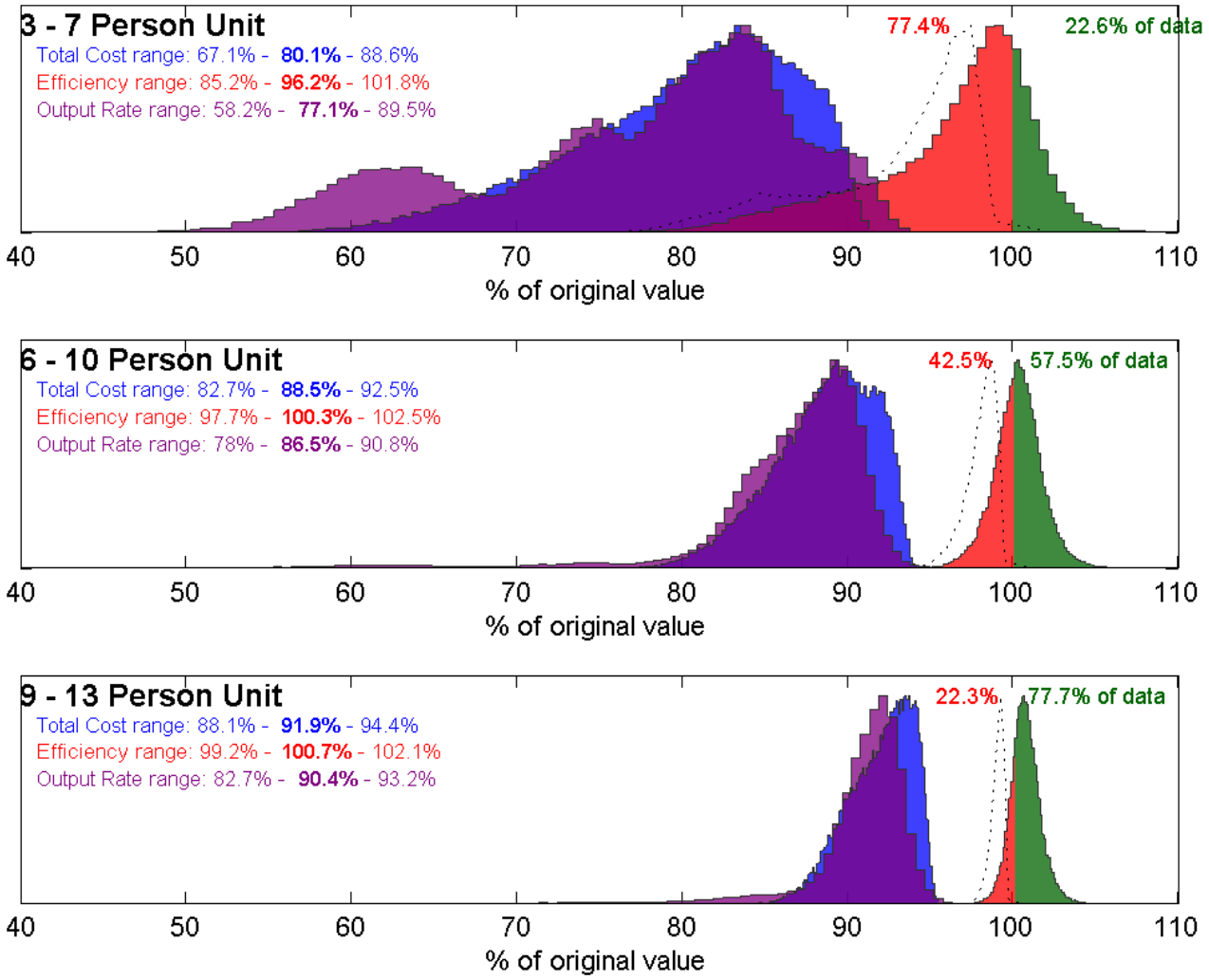
	Output 1	Output 2	Output 3	Output 4	Admin	Prof Dev.	Leave
Person 1	.2	.24			.31	.08	.17
Person 2	.1	.4	.13	.11	.01	.08	.17
Person 3			.53	.21	.01	.08	.17

POE²M – Efficiency Modeling

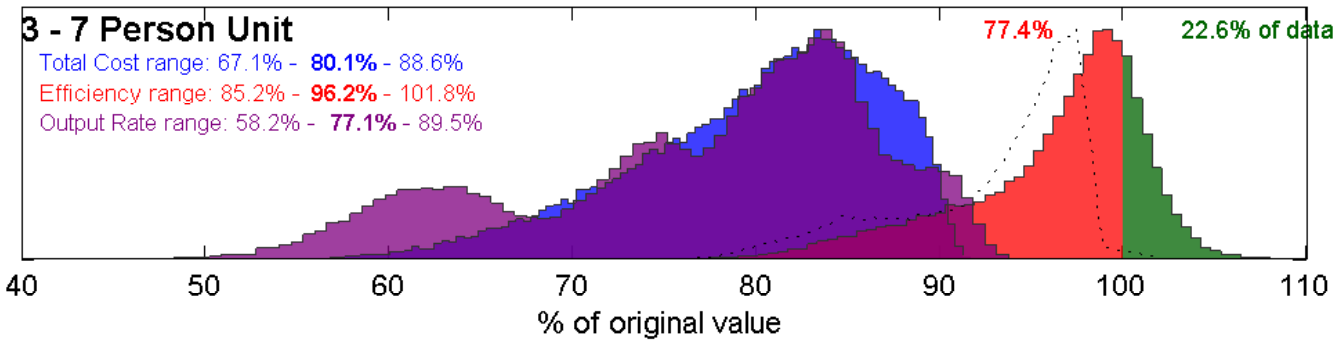
- The outputs of the Monte Carlo simulations are presented in a comparative graphical format that contains a lot of information – these need to be simplified for senior managers, but they provide a wealth of readily comparable data for analysts to interpret

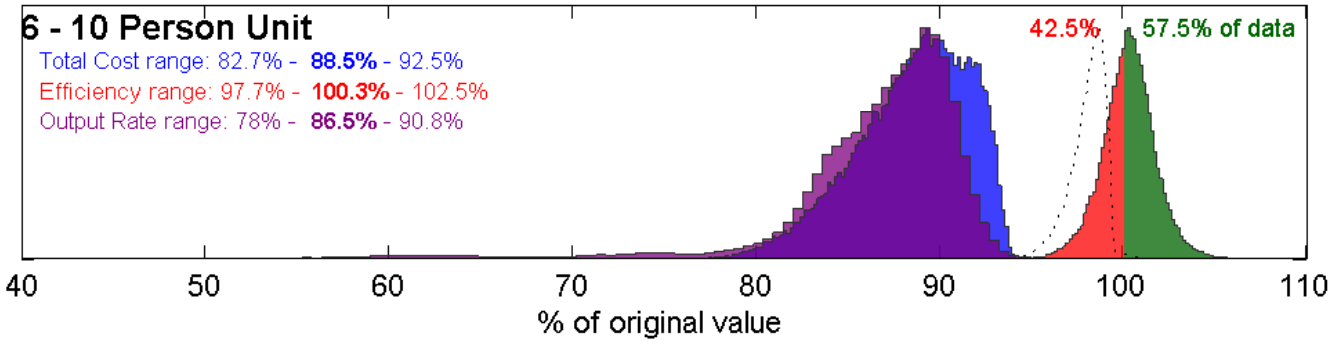
- On these figures:
  - Red/Green – efficiency
  - Blue – cost
  - Purple – output rate
  - Dotted line – efficiency assuming perfect productivity

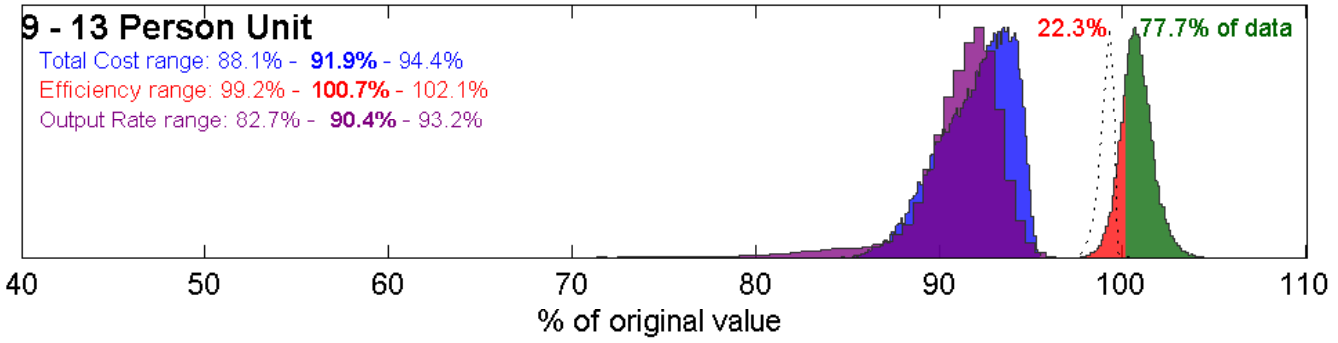
POE²M – Efficiency Modeling



POE²M – Efficiency Modeling







POE²M – Effectiveness Modeling

- What is effectiveness?
- There are innumerable definitions of effectiveness, both within the program evaluation literature and throughout the cognate fields

- We choose to use a simple definition:
  - The extent to which a [program, activity]'s outputs produce the intended outcomes
- Even with fairly simple logic models, the true relationship between output production and outcome(s) can be difficult to articulate cogently

POE²M – Effectiveness Modeling

- Within DND / CF, responsibility for evaluating the success of organizations rests with an internal review agency
  - Their assessment is typically limited to assessing the extent to which organizations are following their approved work programs, and the extent to which outcomes are being achieved

- By mandate, these evaluations do not typically assess or evaluate the logic of the logic model underlying the program of work, nor the actual relationship between outputs and outcomes

POE²M – Effectiveness Modeling

- Our interest (in effectiveness) lies in assessing the extent to which organizations are achieving their specified outcomes

- Eventually, we hope to achieve the ability to benchmark and evaluate our quantification of effectiveness

- Currently, this is beyond our ability as the data for effectiveness are scarce and not necessarily appropriate for use as we desire

POE²M – Effectiveness Modeling

- Based on our review of the extant literature on program effectiveness, we differentiate four aspects of effectiveness we find important:
  - Coverage
  - Redundancy
  - Alignment
  - Effectiveness
- We have built a simple Excel spreadsheet to collate this information

Coverage = **66.7%** (% of outcomes supported by 1 or more outputs / subordinate outcomes)

Redundancy = **16.7%** (% of outcomes supported by 2 or more outputs / subordinate outcomes)

Alignment = **36.4%** (% of outputs / subordinate outcomes which supports an outcome)

		Outcome 1	Outcome 2	Outcome 3	Outcome 4	Outcome 5	Outcome 6
		1	2	1	1	0	0
Output 1	16.7%	1					
Output 2	0%						
Output 3	16.7%				1		
Output 4	0%						
Output 5	33.3%		1	1			
Output 6	0%						
Output 7	16.7%		1				
Output 8	0%						
Outcome 1 (subordinate)	0%						
Outcome 2 (subordinate)	0%						
Outcome 3 (subordinate)	0%						

POE²M – Effectiveness Modeling

Coverage = **66.7%** (% of outcomes supported by 1 or more outputs / subordinate outcomes)

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Output 1	16.7%	1					
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Output 3	16.7%				1		
Output 4	0%						
Output 5	33.3%		1	1			
Output 6	0%						
Output 7	16.7%		1				
Output 8	0%						
Outcome 1 (subordinate)	0%						
Outcome 2 (subordinate)	0%						
Outcome 3 (subordinate)	0%						

POE²M – Effectiveness Modeling

- Coverage
  - Represents the degree to which each expected outcome is supported by (at least) one output
- Redundancy
  - Represents the degree to which each outcome is supported by more than one output
- Alignment
  - Represents the degree to which the outputs are directly supporting each outcome

POE²M – Effectiveness Modeling

- Effectiveness (DBI)
  - The DBI (Donohue-Billyard Index) represents a simple product of the other three indices (Coverage, Redundancy and Alignment)
  - Higher values of the DBI will represent “more effectiveness”
  - It will be a unitless measure that will need to be better described and understood before we can recommend it’s promulgation to the broader evaluation community

POE²M – Conclusions

- Efficiency Modeling
  - Shown that efficiency modeling can be done using our model in controlled circumstances with known or estimated parameters
  - Important to keep in mind impacts on productivity
- Effectiveness Modeling
  - Proposed an effectiveness framework that we feel provides more robust analytical data that can better inform effectiveness decisions
- General Conclusions
  - External peer review of this Efficiency and Effectiveness modeling work is in progress

POE²M – Selected References

- Donohue & Billyard (2012). *Practical Organizational Efficiency and Effectiveness Modeling (POE²M)*. Presentation at 29 ISMOR, 27 AUG 2012. Defence R&D Canada – CORA.
- Donohue & Billyard (in progress). *Practical Organizational Effectiveness Modeling*. Paper to be presented at the Annual Meeting of the Canadian Evaluation Society, June 2013.
- Billyard & Donohue (under review). *Practical Organizational Efficiency Modeling*. Paper submitted to Journal of Productivity Analysis.
- Billyard & Donohue (2012a). *Modeling Efficiencies Update*. Presentation at Formation Institutional Change Management Steering Committee, MARLANT HQ, January 2012.
- Billyard & Donohue (2012b). *Administrative Effects on Organizational Efficiency*. DRDC CORA Letter Report LR 2012-143, 3552-1 (SPORT), June 2012.

POE²M – Contacts

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