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INSTITUTE FOR DEFENSE ANALYSES

Analyses for the National Commission on the Structure of the Air Force (Presentation)

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June 2014
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WEAI
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IDA | Background

- Commission established January 2013
- Impetus: Congressional skepticism of Active/Reserve choices made by Air Force (AF)
- Goal: Undertake a comprehensive study of AF structure to determine force structure modifications to fulfill missions with available resources
- Some considerations
  - Achieve appropriate balance among Components
  - Maintain rotation of 1:2 for Active and 1:5 for Reserve
- Report due (and delivered) by February 1, 2014
- We started work in mid-November – combination of using existing tools and building simple new ones

Tasking: Address Four Questions

- What are the feasibility and cost implications of maintaining desired Air Reserve Component (ARC) strength levels with an ARC that is expected to be voluntarily activated one-sixth of the time?
- What are the cost implications of having a more Reserve-intensive F-16 force?
- What are the cost and availability implications of placing more Security Force assets in the ARC?
- What are the cost implications of using more ARC pilots to provide initial pilot training?

IDA | Maintaining an ARC Mobilization:Dwell Ratio of 1:5

- Focus: the recruiting and retention consequences
- Drew on Reserve Component Simulation Model (R-SIM) to forecast response to
  - Different activation policies
  - Alternative compensation
  - Previously unoffered contract options
- Estimate preferences based on choices over ten-year period
  - Importance of compensation
  - Willingness to serve
  - Apply preferences to predict responses to hypothetical situations
- Aspects of analysis
  - Novel model accounts for attitudes of RC members' attitudes towards and experience of active duty
  - Period of observation includes both peacetime and extended conflict
  - Modeled each Reserve Component separately

Data and Modeling Overview

- R-SIM was estimated using data on activations in support of named contingencies
- During the height of Operation Enduring Freedom/ Operation Iraqi Freedom (OEF/OIF), these data indicated a rotation rate of about 1:9
- Some active duty is not captured in these data (not served in official support of a contingency)
- We examined two interpretations of the motivating question
  1. Sustaining wartime active duty rates (R-SIM 1:9) indefinitely (this implicitly includes ALL active duty served in OEF/OIF)
  2. Sustaining R-SIM 1:5 (may correspond to true rates that are actually in excess of 1:5)

IDA | Results for Prior Service Recruits

	Accessions	Strength	Available
R-SIM Baseline (OEF/OIF)	100%	100%	100%
1:9 Indefinitely	72%	92%	92%
1:5 Indefinitely	64%	109%	181%
1:9 with $10K/yr extra	105%	115%	115%
1:5 with $10K/yr extra	75%	120%	200%

- Higher rotation rates reduce accessions
- However, they induce high retention among those with a higher "taste for service"
- Consequently, total strength is not greatly affected
- Increasing the rotation rate increases the fraction of the force that is available at any given time

IDA | Implications of Tailoring Contracts to Tastes

	Accessions	Strength	Available
R-SIM Baseline (OEF/OIF)	100%	100%	100%
Contract Choice 1:10 or 1:8	72%	95%	104%
Contract Choice 1:6 or 1:4	64%	116%	223%

- Offering alternative contracts with a “high” and “low” rotation commitment option
  1. Allows recruits to select their preferred level of tempo
  2. Increases the available force because many self-select for higher tempo

Cost Implications of a More RC-Intensive F-16 Force

- Uses IDA's Total Force Cost Methodology for the AF
  - Most cost factors from AF sources
  - Inputs include force size, mix, and BOG-to-Dwell ratio for AC, MOB-to-Dwell for RC
  - Outputs are annual cost for the force and potential deployment capability
- Some characteristics of analysis
  - Training at normal historical rates, with some excursions
  - AC and AF Reserve squadrons have 24 aircraft, Air National Guard (ANG) have 21
  - Deployments of 120 days with adjustment for more rapid pilot rotation
  - BOG-to Dwell of 1:2, 1:3; MOB-to-Dwell of 1:5, 1:7

IDA | Squadron Annual Costs

	ACC	USAFE	PACAF	AFR	ANG
Primary Aircraft Authorization (PAA)	24	24	24	24	21
Flying Hours/PAA/Year	312	336	280	233	180
Cost Element ($M)					
Unit-Level Personnel	53.1	73.8	76.8	52.2	35.9
Unit Operations	35.6	38.4	32	26.6	18.0
Maintenance and Support	76.7	98.7	88.8	46.9	58.3
Continuing System Improvements*	9.4	9.4	9.4	9.4	8.2
Total	**177.8**	**220.4**	**207.0**	**135.2**	**120.4**
Cost/PAA/Year ($M)	**7.41**	**9.18**	**8.63**	**5.63**	**5.74**

* Allocated on basis of fraction of procurement cost and number of aircraft

- ARC is about 20% cheaper than Air Combat Command
- AF Reserve and ANG similar: Guard flies less but has higher support costs

IDA | Results of Exploratory F-16 Analysis

	BOG-to-Dwell 1:2, MOB-to-Dwell 1:5							
	Baseline			Shift to RC			Tiered RC Readiness	
	AC	RC	Total	AC	RC	Total	RC	Total
Rotating	175	300	475	143	360	503	360	503
Forward Stationed	50	0	50	32	0	32	0	32
Total PAA	225	300	525	175	360	535	360	535
Annual Cost ($M)	2,323	2,213	4,536	1,804	2,656	4,459	2,351	4,055
Rotationally Deployed			108			108		108

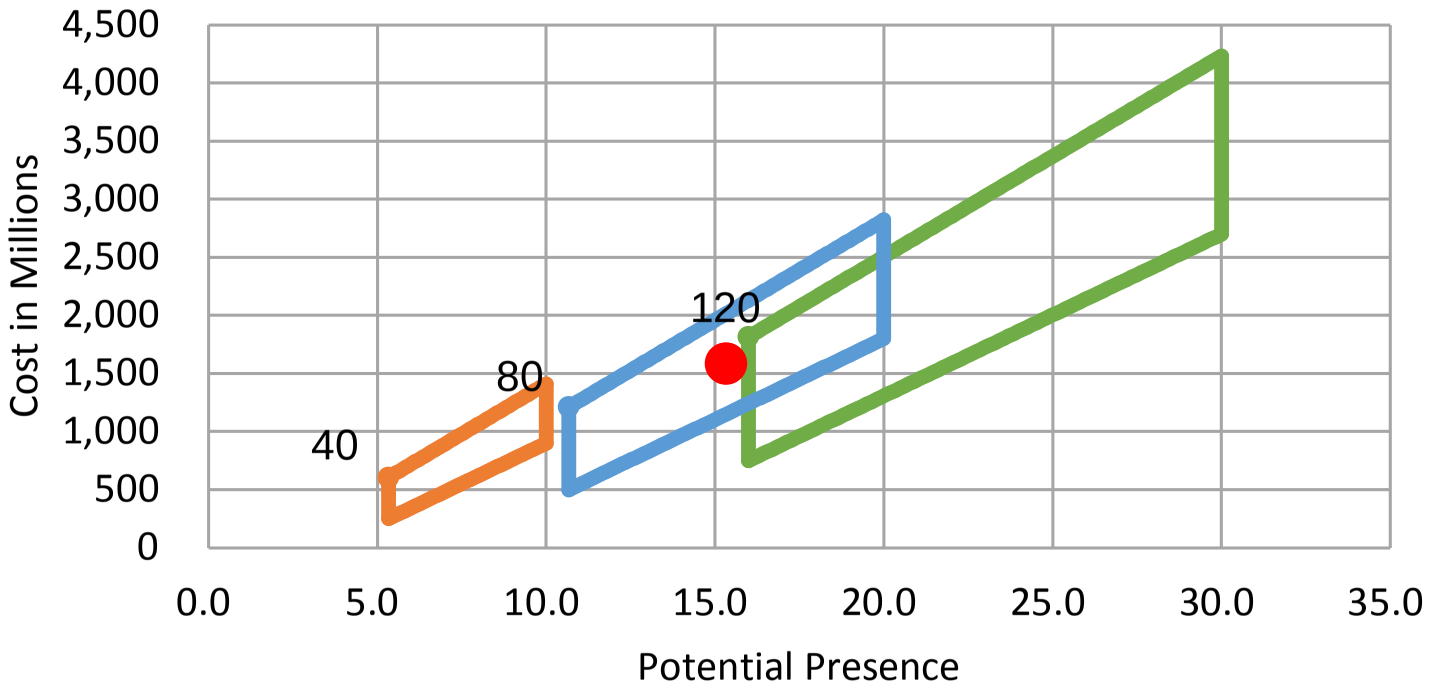
- A shift to the RC and reduced forward stationing can yield same rotational capability and slightly increase force size at similar cost
- Reducing RC readiness until period before planned deployment could save money

IDA | Placing More Security Assets in the ARC

- Data on Air Force unit operating costs only cover flying units
  - We used Army model: Army MP battalion (170 people) stood in for Air Force Base Defense Squadron (200 people)
- Assumed greater use of ARC consistent with CONUS mission
- Question: What are the cost implications of providing rotationally deployed presence with alternative AC-RC mixes?
- Examined various BOG-to-Dwell and MOB-to-Dwell ratios
- Varied percentage of time available units would deploy

Cost and BOG Generation at 1:3/1:5						
	Active			National Guard		
	Annual Cost Per Airman ($K)	Available BOG/unit	BOG/unit	Annual Cost Per Airman ($K)	Available BOG/unit	BOG/unit
Available Units Do Not Deploy	132	0.25	0.00	37	0.13	0.00
Available Units Deploy	207	0.25	0.25	89	0.13	0.13

Examination of Alternative Force Structures



- Three force sizes illustrated: 40, 80, and 120 battalions
- Reserve-intensive force structures can provide presence less expensively even with more units
- CONUS requirements are not considered in this analysis

IDA | Using More ARC Instructors to Provide Initial Pilot Training

- Most initial pilot training is provide by AC instructors
  - Many are fighter pilots
  - Every active instructor is one more active pilot in the force who must be trained
  - Additional ARC instructors are already trained
- Training fighter pilots is very expensive
  - $3.6 million for initial qualification
  - $2.7 million for requalification after filling non-fighter billets
- RC instructors could provide initial training on a rotating basis
  - Already fully trained
  - No need for requalification training after assignment

Assumptions

- Additional trained pilots can be attracted to the ARC
- Active fighter pilot turnover rate is 10%; $360K initial training cost per year
- All AC instructors return to flying billets and must be retrained after 3 years; $900K retraining cost per year
- ARC instructors fly 60 days/year, AC instructors fly 200; each spends 2 days solely maintaining proficiency
- ARC pilots cost $13K more than AC pilots per billet filled

Findings

- Net savings per billet converted ≈ $1.4M per year

IDA | Summary

- We largely used existing tools to quickly address issues raised by the Commission on the Structure of the Air Force
  - Demonstrates the value of building institutional capability
- We found that
  - A 1:5 Mobilization:Dwell ratio appears feasible for the ARC
  - A more RC-intensive F-16 force can generate rotational capability and make a slightly larger force structure affordable
  - A more RC-intensive Security Force has similar characteristics, but even more so
  - The use of ARC instructor pilots can yield savings
- The Commission cited our pilot training findings and the Air Force has shown interest

BACK-UPS

R-SIM Inputs and Outputs

- R-SIM Inputs
  - Military eligible population
  - Peace/war transition probabilities
  - Dwell times (by war state)
  - Active duty lengths (by war state)
  - Military and civilian income at each year of service
  - Youth unemployment rate (age 18–24)
  - Casualties (land components only)
- R-SIM predicts strengths for different policies and situations
  - Number of enlisted accessions by Fiscal Year (FY)
  - Enlisted end strength by year of service and FY
  - Enlisted continuation rates by year of service and FY

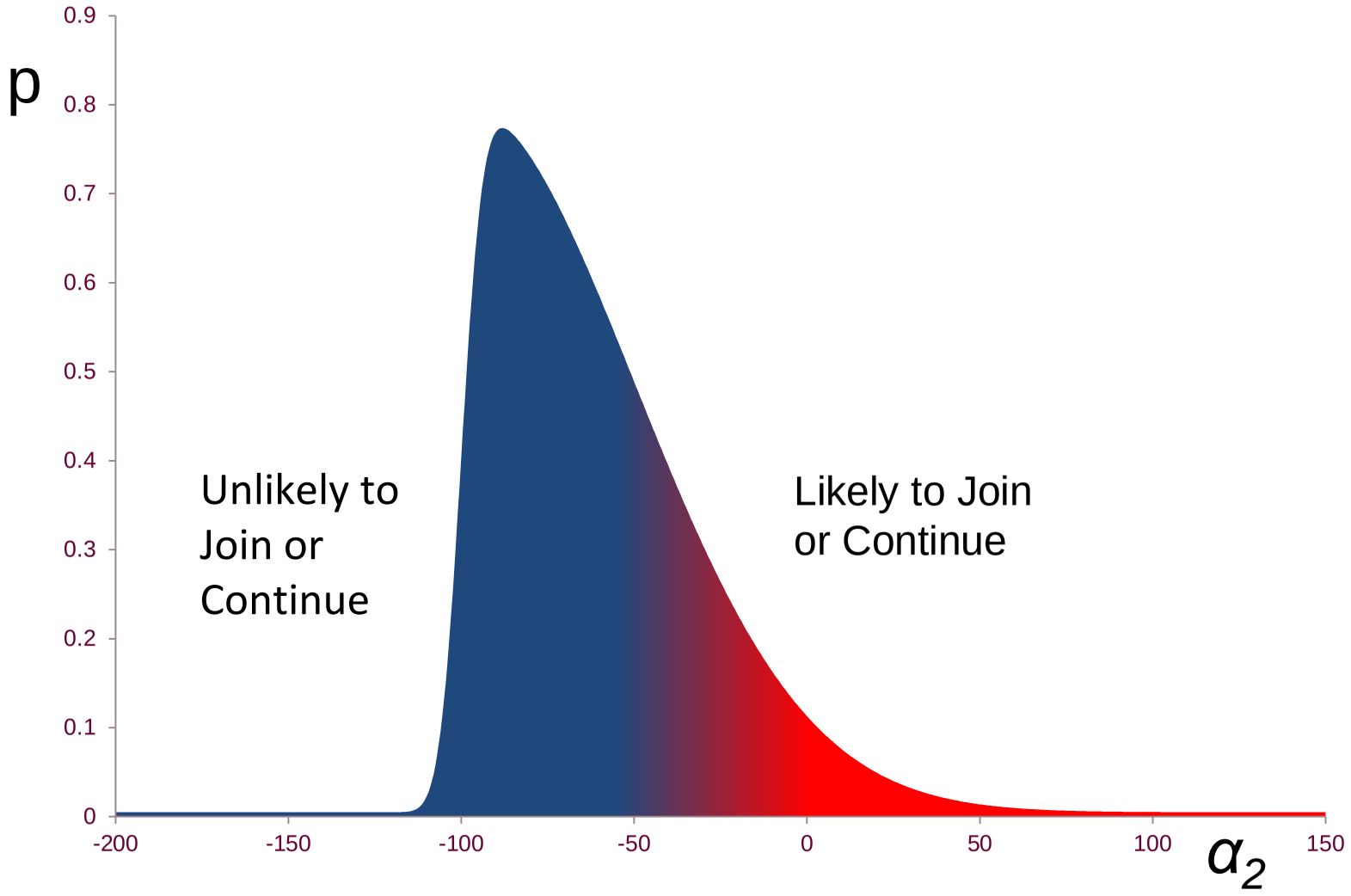
IDA | The R-SIM Model

- Young civilians decide in each year whether to join the Selected Reserve
- Reservists and Guardsmen decide in each year whether to stay or leave
- They compare the benefits from leaving in the current year with the benefits from staying until retirement eligibility
- To make this decision, they consider
  - Money income
  - The amount of time that they spend on active duty (past, present, and future)
  - Random events
  - The likelihood of future war
- Each civilian (and Reservist/Guardsman) has a different preference for their ideal amount of active duty
- These preferences are described by a statistical distribution covering the entire population, α_2

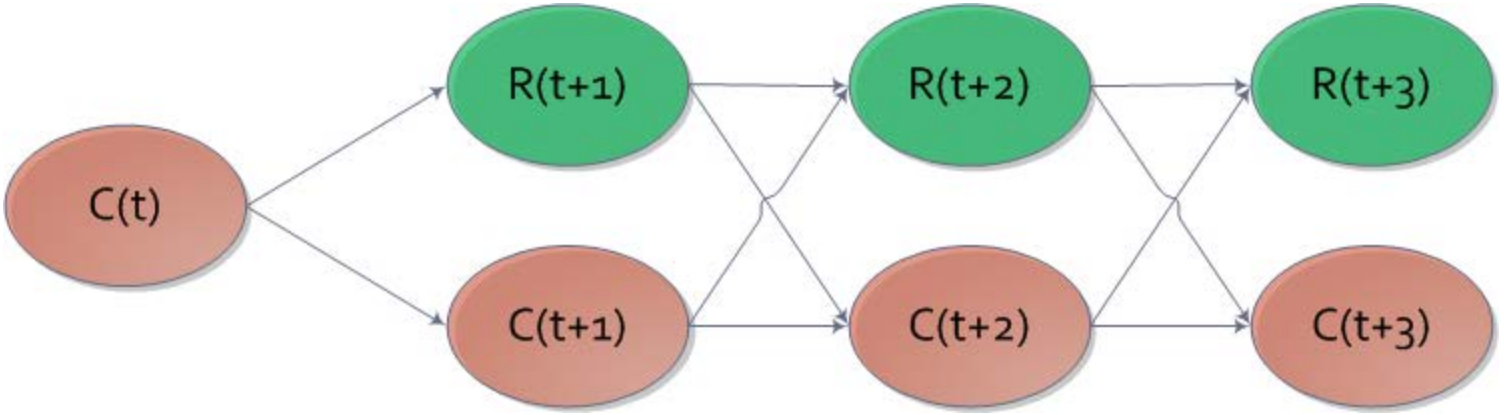
R-SIM Preferences

- α_2 represents an individual's preference for military service or willingness to serve
- A unique α_2 is drawn from a skew-normal distribution for each individual
- Individuals have either a positive or negative preference for service based on their unique α_2 draw
- α_2 is distributed skew-normal
- Location, scale, and shape parameters determine the shape of the distribution

Illustrative Distribution



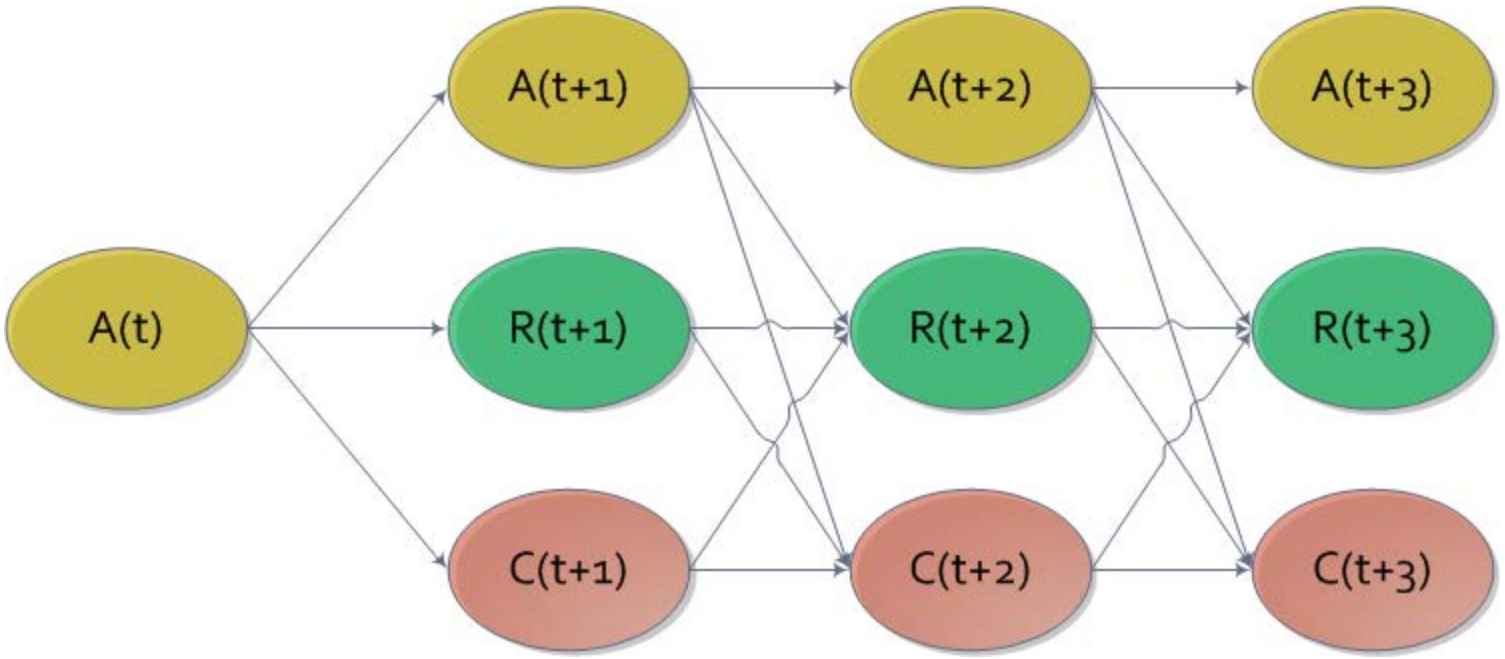
Non-Prior Service Decision Model



- R = Reserve
- C= civilian

* Note: an individual can only join the Reserve one time. Once he leaves, he remains in the civilian state.

Prior Service Decision Model



- A = Active force
- R = Reserve
- C= civilian

* Note: an individual can only join the Reserve one time. Once he leaves, he remains in the civilian state.

Estimation Method: R-SIM Decisions

- Individuals join/continue if: $Utility > 0$

$$Join\_Utility_{t,i} = \alpha_m ACOL_{t,i} + \alpha_{2_i} S_{t2} + \alpha_c Casualties_t + \alpha_u Unemployment_{t,i} + \phi_{j_{t,i}}$$

$$Stay\_Utility_{t,i} = \alpha_m ACOL_{t,i} + \alpha_{2_i} S_{t2} + \phi_{s_{t,i}}$$

  - $ACOL$: Annualized money cost of leaving
  - α_2: Preference for service
  - S_{t2}: Discounted sum of squared months on active duty
  - ϕ: Mean zero shocks

- Based on the Canonical ACOL-2 model of retention:

$$Stay\_Utility_{t,i} = ACOL_{t,i} + \alpha_i + \phi$$

Deriving ACOL

- Military/civilian income differential and unique activation schedules determine ACOL
- Match military and civilian earnings using RAND compensation data to determine the income differential
- Use activation schedule to determine time activated for each individual

$$COL_t = (MilActiveEarn_t - CivEarn_t)(Active_t) + MilInactiveEarn_t(1 - Active_t)$$

- ACOL is the present value of all future COLs, expressed as an annualized amount.

Deriving S_{t2}

- Factors determining individual's unique activation schedule:
  - Peace/war transition probabilities
  - Distribution of dwell times in wartime
  - Distribution of active duty lengths in wartime
  - These distributions are taken from the experience of all serving in the reserve component 2002–2009
- Use activation schedule to determine S_{t2}
  - Compute squared cumulative months on active duty at each month and take the discounted sum

Calibration Data

- Data includes 20+ million observations of enlisted Service members from 2000 to 2009
  - All Services
  - Reserve and Guard Components
- Personnel files (include joining and staying)
- Activation files (dates of all individual activation and dwell times)
- RAND earnings file (matches military and civilian earnings of groups of Reservists based on Social Security Administration data)

Calibration Method

- The calibrated parameters are α_m, α_c, α_u, $\phi_{j_{t,I}}$, $\phi_{s_{t,i}}$ and the location, scale, and shape parameters of the α_2 distribution
- We use the Nelder-Mead polytope optimization method to find the parameters that produce the best match to actual military strength and continuation rate data
  - Many thousands of simulated Service members are randomly drawn from the R-SIM population distribution
  - Each Service member makes joining and staying decisions
  - Minimize square difference between predicted and actual accession/continuation data
  - Accession is measured by total number joining per year
  - Continuation is measured as the percentage of Service members continuing to the next year of service
  - Weigh accession and continuation cells equally
- We calibrate to years 2000–2006

Optimization Equation: Non-Prior Service

$$Percent\_error = \frac{20}{7}\sum_{t=2000}^{2006}\left(\frac{actual\_join_t - predicted\_join_t}{actual\_join_t}\right)^2 +$$

$$\sum_{t=2001}^{2006}\left(\frac{actual\_contin_{1,t} - predicted\_contin_{1,t}}{actual\_contin_{1,t}}\right)^2 + \ldots +$$

$$\sum_{t=2005}^{2006}\left(\frac{actual\_contin_{5,t} - predicted\_contin_{5,t}}{actual\_contin_{5,t}}\right)^2$$

$$contin_{N,t} = \frac{\text{strength in YOS N in year t}}{\text{strength in YOS N-1 in year t-1}}$$

Air Guard Non-Prior Service Fit Example

Actual Join	% Error	YOS1											
4904	6.18%	Actual Continuation	% Error	YOS2									
5600	-5.45%	90.74%	3.05%	Actual Continuation	% Error	YOS3							
4729	-21.06%	89.14%	8.07%	93.10%	5.45%	Actual Continuation	% Error	YOS4					
4052	-6.91%	87.99%	-0.69%	92.05%	-6.89%	92.52%	-2.18%	Actual Continuation	% Error	YOS5			
3877	5.47%	89.51%	-0.48%	92.41%	-0.84%	94.15%	-2.16%	94.13%	0.15%	Actual Continuation	% Error		
3287	28.41%	90.82%	-5.64%	93.66%	-1.59%	94.75%	0.67%	94.85%	0.67%	94.43%	2.47%		
3951	1.27%	90.39%	-8.63%	93.47%	-3.21%	93.46%	1.81%	93.71%	3.34%	95.10%	1.51%		

Absolute Percent Error

Non-prior Service	Join Fit	Continuation Fit	Overall
Army Guard	30%	6%	18%
Army Reserve	33%	9%	21%
Air Guard	11%	3%	7%
Air Reserve	21%	5%	13%
Marine Corps Reserve	24%	5%	15%
Navy Reserve	36%	8%	22%
Prior Service			
Army	26%	10%	18%
Air	26%	7%	17%

Optimization Equation: Prior Service

$$
\begin{aligned}
&Percent\ Error \\
&= \sum_{yos=4}^{7} \left[\frac{8}{5} \sum_{t=2001}^{2006} \left(\frac{actual_{join\ yos,t} - predict_{join\ yos,t}}{actual_{join\ yos,t}} \right)^2 \right. \\
&+ \sum_{t=2002}^{2006} \left(\frac{actual_{contin\ yos,yos+1,t} - predict_{contin\ yos,yos+1,t}}{actual_{contin\ yos,yos+1,t}} \right)^2 \\
&+ \sum_{t=2003}^{2006} \left(\frac{actual_{contin\ yos,yos+2,t} - predict_{contin\ yos,yos+2,t}}{actual_{contin\ yos,yos+2,t}} \right)^2 \ldots \\
&\left. + \sum_{t=2006}^{2006} \left(\frac{actual_{contin\ yos,yos+5,t} - predict_{contin\ yos,yos+5,t}}{actual_{contin\ yos,yos+5,t}} \right)^2 \right]
\end{aligned}
$$

$$
\begin{aligned}
&contin_{N,N+j,t} \\
&= \frac{strength\ \ in\ YOS = N + j\ in\ year\ t\ who\ joined\ with\ N\ years\ of\ active\ service}{strength\ \ in\ YOS = N + j - 1\ in\ year\ t - 1\ who\ joined\ with\ N\ years\ of\ active\ service}
\end{aligned}
$$

IDA | Model Fit – Ex. Air, Prior Service (1 of 2)

	Join in YOS4	% Error	YOS5 Actual Continuation	% Error	YOS6 Actual Continuation	% Error	YOS7 Actual Continuation	% Error	YOS8 Actual Continuation	% Error	YOS9 Actual Continuation	% Error
2001	1260	-2.06%	91.95%	2.85%	71.25%	-6.79%	71.93%	-0.08%	87.80%	-10.44%	83.33%	-3.84%
2002	482	47.30%	90.63%	-0.07%	72.41%	14.90%	66.67%	32.34%	78.57%	19.72%		
2003	480	38.75%	90.32%	1.07%	89.29%	-8.82%	76.00%	16.69%				
2004	664	21.54%	94.12%	-3.62%	89.06%	-9.19%						
2005	884	11.54%	95.79%	-3.33%								
2006	799	18.40%										

	Join in YOS5	% Error	YOS6 Actual Continuation	% Error	YOS7 Actual Continuation	% Error	YOS8 Actual Continuation	% Error	YOS9 Actual Continuation	% Error	YOS10 Actual Continuation	% Error
2001	172	33.14%	89.84%	3.04%	78.36%	-21.74%	84.55%	-19.94%	84.00%	-8.01%	88.41%	-8.52%
2002	639	-72.46%	84.23%	3.20%	89.41%	-7.16%	82.92%	8.25%	87.71%	7.01%		
2003	549	-20.95%	86.67%	5.81%	81.01%	2.66%	86.05%	4.27%				
2004	384	-20.31%	86.60%	0.76%	85.74%	-4.77%						
2005	530	-30.19%	90.38%	1.97%								
2006	379	-47.76%										

Model Fit – Ex. Air, Prior Service (2 of 2)

	Join in YOS6	% Error	YOS7 Actual Continuation	% Error	YOS8 Actual Continuation	% Error	YOS9 Actual Continuation	% Error	YOS10 Actual Continuation	% Error	YOS11 Actual Continuation	% Error
2001	127	26.77%										
2002	135	-5.93%	88.95%	4.74%								
2003	293	-39.25%	87.32%	1.89%	77.12%	-13.56%						
2004	342	-20.76%	86.52%	6.49%	84.41%	-3.55%	80.51%	-13.05%				
2005	675	2.81%	83.59%	7.71%	78.74%	3.00%	81.95%	6.10%	81.05%	-3.06%		
2006	738	-7.18%	91.89%	-2.15%	81.62%	-2.09%	77.27%	14.82%	87.31%	10.24%	89.61%	-2.61%

	Join in YOS7	% Error	YOS8 Actual Continuation	% Error	YOS9 Actual Continuation	% Error	YOS10 Actual Continuation	% Error	YOS11 Actual Continuation	% Error	YOS12 Actual Continuation	% Error
2001	205	5.85%										
2002	112	10.71%	90.55%	3.31%								
2003	130	0.00%	84.44%	4.10%	68.70%	-12.51%						
2004	208	-43.27%	88.74%	2.29%	78.95%	3.43%	81.01%	-14.00%				
2005	383	-44.13%	86.84%	3.44%	82.69%	2.48%	88.89%	-3.93%	87.50%	-13.95%		
2006	351	-51.57%	88.59%	-0.84%	80.47%	0.82%	79.53%	10.64%	90.00%	3.80%	87.50%	-12.50%

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13. SUPPLEMENTARY NOTES

14. ABSTRACT

This document presents four short analyses performed by the Institute for Defense Analyses (IDA) for the National Commission on the Structure of the Air Force, which was established by the National Defense Authorization Act for Fiscal Year 2013. Each analysis addresses an issue raised by the Commission staff regarding possible changes to the use of Air Reserve Component (ARC) forces that could enhance the overall efficiency of the Air Force. The analyses address the following questions: What are the feasibility and cost implications of maintaining desired ARC strength levels with an ARC that is expected to be voluntarily activated one-sixth of the time? What are the cost implications of having a more Reserve-intensive F-16 force? What are the cost and availability implications of placing some Security Force assets in the ARC? What are the cost implications of using more ARC pilots to provide initial pilot training?

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