Picking a Representative Sample For CMMI® Enterprise Appraisals

Raytheon
Intelligence and Information Systems (IIS)

Enterprise CMMI® ML3 SCAMPI(SM) SE/SW/IPPD/SS

#5382

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Ray Kile has thirty-seven years experience and is an SEI Certified High-Maturity Lead Appraiser and Instructor with a PMI PMP certification. He developed the REVIC model used widely by the US DOD and contractors and is Chief Engineer at The Center for Systems Management where he teaches Process Improvement, Software Cost Estimating, Project Management, and Systems Engineering courses. He has participated in well over a hundred CMMI SCAMPI A appraisals up through Maturity Level 5 and ARC Class C-type appraisals. Ray holds a BSEE from the United States Air Force Academy and a MSEE from the University of Missouri.

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Kathy has twenty-two years experience as a multi-discipline engineer and project manager, Raytheon Six Sigma™ Expert, Assessment Lead for Raytheon Intelligence and Information Systems (IIS) Enterprise Process Team (EPT), and member of the Raytheon Technology and Process Councils. She is a Technology Award winner, an Operational Excellence Award winner, and a Space Systems Process Improvement Award winner. Kathy holds degrees in Physics, Astronomy, Mathematics, and Music.

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rements of the MDD

- **Picking a representative sample for an Enterprise appraisal leading to a maturity level rating is a multi-faceted problem. You must pick a sample that:**
  - ï Reflects the diversity in the organization
  - ï Satisfies the needs of the community-at-large to ensure credibility
  - ï Complies with the requirements of the SCAMPI Methodology Description Document (MDD)
  - ï Meets the organizations requirements from both an economic and schedule perspective.
- **Recently the MDD has undergone revision to version 1.2 and section 1.1.3 which addresses sampling requirements.**
- **The new MDD requires identifying “critical factors” that:**
  - ï use the organizationôs standard processes
  - ï provides adequate coverage of all the critical factors for the appraisal.
- **At last year’s SEPG a Design of Experiments approach was described; however, it relied on a statistically valid set of appraisal data as input and is not feasible for many organizations.**

u select a representative an enterprise?

- **Objectives:**
  - Determine a set of candidate programs for an appraisal that truly represent the enterprise
  - Determine a manageable representation that allows for an assessment to be completed effectively and efficiently
- **There are fundamental concepts that will allow you to effectively and confidently characterize an enterprise.**
  - Enterprise Factor Analysis: Determine the characteristics that most accurately represent your enterprise using techniques such as Histograms, Pareto Diagrams, Weighted Decision Matrix (WDM), statistical computations, Graphical representations,é
  - Enterprise Interactions ID: Identify any factors where a change in 1 factor makes a corresponding change in another factor. This may be useful to reduce the total number of factors needed to characterize your enterprise.
  - Enterprise Key Factors Selection: Identify the factors which best represent your enterprise based on the factor analysis.
  - Project Selection: Identify programs that best match these characteristics.
- **This paper will walk through the methodology used by IIS and the analysis performed to characterize the enterprise and select the representative sample.**

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- CMMI v1.1 ML3 SE/SW/IPPD/SS 12/01/2006, ADS v1.2
  - Team of 9, including 1 SEI High Maturity Lead Appraiser + 3 SEI Lead Appraisers
  - 5 weeks on-site for Class A, 138 interviewees
- IIS has over 300 programs in five major product lines, with 8,000 employees (additional 1800 in IT services unit not included in this appraisal).
- Work is performed at six primary sites, and multiple secondary and customer sites around the world.
- Programs and product lines span multiple work sites, but not all programs or product lines are represented at all work sites.
- There is a mix of classified and unclassified programs at each site and within product lines.
- Programs range from a few engineers maintaining small systems or prototyping new capabilities, to hundreds of engineers working in a multi-site, integrated development environment to create and deliver complex mission systems.
- IIS programs are not production systems, such as aircraft, appliances, or missiles, so program characteristics of the organization or a product line can change significantly in relatively short periods of time to meet customers' changing needs.

se a Design of Experiment haracterize IIS?

- **The ability to perform a DOE of such an aggregation is an increasingly complex problem.**
  - ï Collecting even a limited set of characteristics, such as 5 or 6, on 300+ programs is a far more time consuming and costly venture then collecting a dozen characteristics on 10 programs.
  - ï No experimentation will ever occur which changes the precepts of a DOE.
  - ï Factors can only be used to find a ñclosestò match to existing programs.
  - ï In dynamic organizations, by the time data is collected for initial aggregation, and statistically analyzed for selection of DOE factors, the basis for the initial characterization may have changed enough to invalidate that basis.
- **The end result**
  - ï DOE quickly becomes unfeasible in large, dynamic enterprises even if the enterprise can support the labor cost, potential impacts to programs, and months needed for the initial collection and aggregation of characterization information, and has the knowledge on-hand to perform a large multi-factor DOE.
- **There are, however, fundamental concepts that can be used to find a sample of programs that truly represent your enterprise.**

se “100% Sampling”?

- **The ability to perform “100% sampling” of such an aggregation is unwieldy and complex.**
  - ï Collecting Objective Evidence (OE) on even 1 or 2 process areas on over 300+ programs is a time consuming and costly venture.
  - ï In dynamic organizations, by the time OE is collected, new programs will have started which must be added to the collection, and other programs will have ended, so the OE no longer accurately reflects the organization. A ñsampling as of <date>òhelps, but will require substantiation.
  - ï Assuming each program provides minimal artifacts for only 1 PA, IIS would have needed to provide and manage over 20,426 artifacts.
  - ï Culturally, this can also drive the wrong behavior: perfection in 1 process area with inadequate or ignored processes in other areas.
- **The end result**
  - ï ñ100% samplingòquickly becomes unfeasible in large, dynamic enterprises even if the enterprise can support the labor cost and potential impacts to programs, and institutes a process to manage the insertion and obsolescence of OE and programs in the organization.

Summary Methodology used by Raytheon IIS

ethodology Used by IIS

- **Identified the characteristics of 300 + programs in the enterprise using:**
  - Org charts
  - Monthly Operations Reviews (MOR) Data
  - 2006 Annual Operating Plan (AOP) (financial tracking)
  - Sit-down session with leaders across the company
- **This information formed the basis for characterizing the enterprise, and provided the baseline to ensure we did achieve a truly representative sample.**
  - Inability to represent your enterprise may drive you to a ñquantityòsolution.
- **Adjudicated 300+ programs down to a set of 178 programs that were viable programs for assessment. Examples of programs eliminated:**
  - program ends prior to 9/2006
  - program award after 9/2006
  - financial challenges
  - capital sales items...
- **Analyzed the program characteristics to determine the most appropriate Enterprise Key Factors.**
- **Compared the 178 programs versus Enterprise Key Factors to down-select to 20 programs to be further analyzed for consideration.**

hodology Used to Select IIS ve SCAMPI Programs (cont.)

- **Implemented a weighted decision matrix to score the 20 programs against the factors.**
- **Analyzed combinations of these 20 programs that provided coverage against the product lines and primary sites.**
- **Identified risks and potential options.**
- **Reviewed the programs with the Product Line Managers to resolve any concerns or issues.**
- **Identified 14 programs for review with the lead appraiser.**
- **Summarized and Reviewed with the appraisers during multi-day meetings:**
  - Representative sample selection process used
  - IIS enterprise characteristics
  - Characteristics of the 14 candidate programs
  - Various combinations of the candidate programs against the enterprise characteristics
- **Selected 7 programs as the enterprise representative sample for the appraisal.**

300+ → 178 → 20 → 14 → 7

Details and Factors

ollection (300+ programs)

- **For the initial data collection, a team of experienced appraisers and program leaders across IIS identified characteristics used in past appraisals, and key characteristics used in day-to-day operations.**
- **Characteristics included:**
  - Pre-acquisition or Post-Award
  - Single or Multi-site programs
  - Development vs O&M
  - CMMI Requirement or existing Objective Evidence baseline.
  - Classified or Unclassified
- **Point of Contact (POC) at each Raytheon IIS site collected this information on existing programs using:**
  - Organization and Staffing Charts
  - Monthly Operations Review Data
  - Sit-down sessions with product area and engineering managers.
  - 2007 Annual Operating Plan (AOP) (contains the financial expectations for all programs in IIS).

ntified During the Initial Data

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- **Some categories were too broad and further detail was needed.**
  - Example: Development vs O&M needed to be expanded to help us understand the scope of a program:
    - System Development but no Development of Software Deliverables
    - System and Software Development
    - Delivered products in O&M with additional development in work
    - O&M not a follow-on to development
    - Service contract
    - Fixed staff level contract
    - Time & Materials contract
    - Other
- **Other factors were identified that impacted the characterization of the enterprise. Examples:**
  - Offsite programs that use prime or customer processes.
  - Some programs are split on-site/off-site, and needed to know relative % of on/off site effort.
- **The data on these factors was then analyzed to select the 20 Candidate Programs.**

Factors Set: Total 21 Factors
ams → 178 programs

- **Multi-site (which sites)**
- **Program office location**
- **% on-site/off-site effort**
- **Program Type:**
  - Development
  - O&M with/follow-on to development
  - O&M not a follow-on to development
  - Service contract
  - Time and Materials
  - Fixed staff
  - Other
- **Appraisal Reuse basis:**
  - Has an existing objective evidence baseline
- **Program Scope: SE, SW, Subcontracts**
- **Contractual CMMI requirement**
- **Product Lines Covered: SS, NS, SIS, TIS, OTS**
- **Pre-acquisition/proposal program or Post-acquisition program**
- **Classification level and special restrictions**
- **Internal Gate Status (lifecycle indicator)**
- **Current engineering/technical staff**
- **Projected engineering/technical staff in 9/2006.**
- **AOP Contract value in 2006.**

Factors Analysis Example: laturity/Gate

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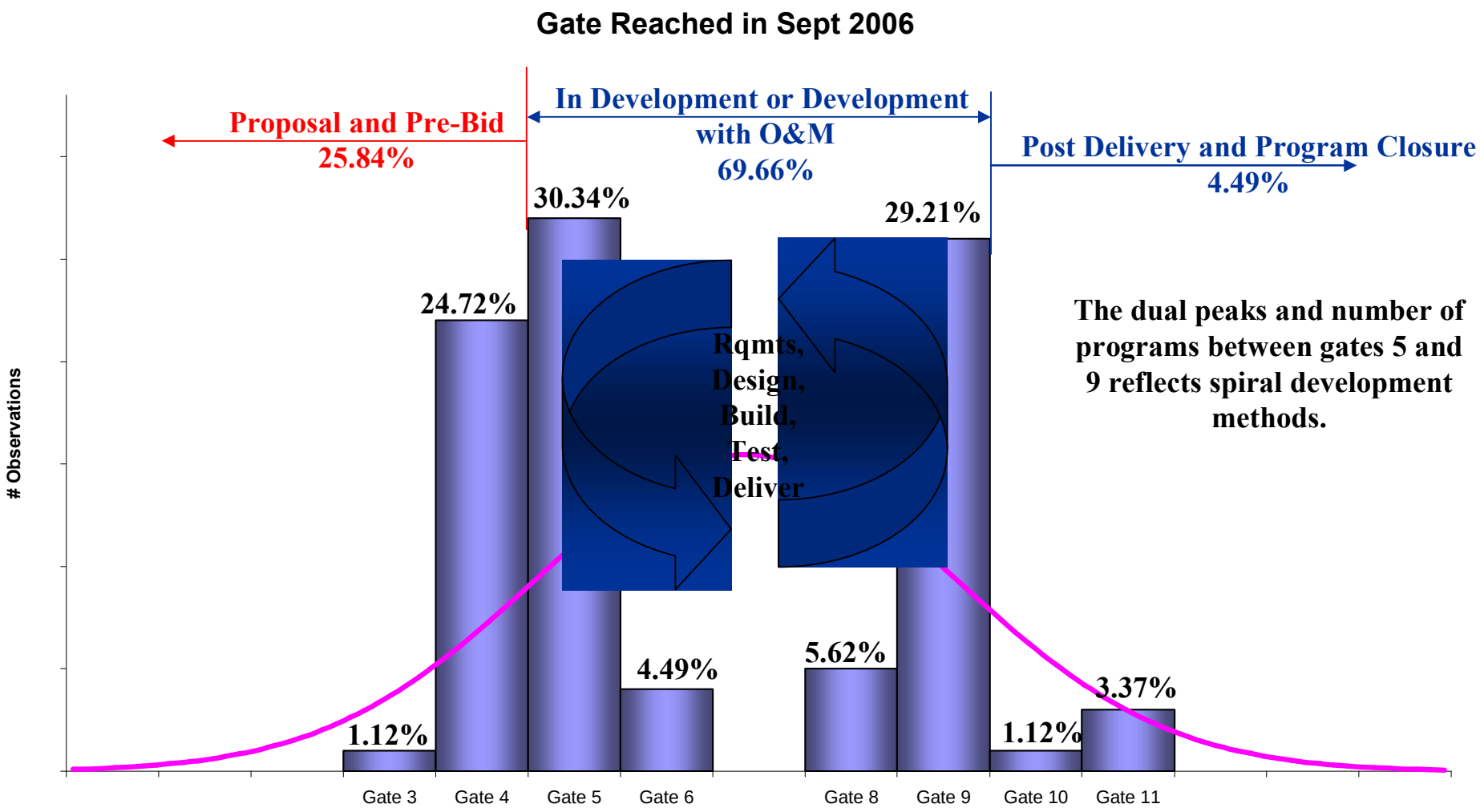
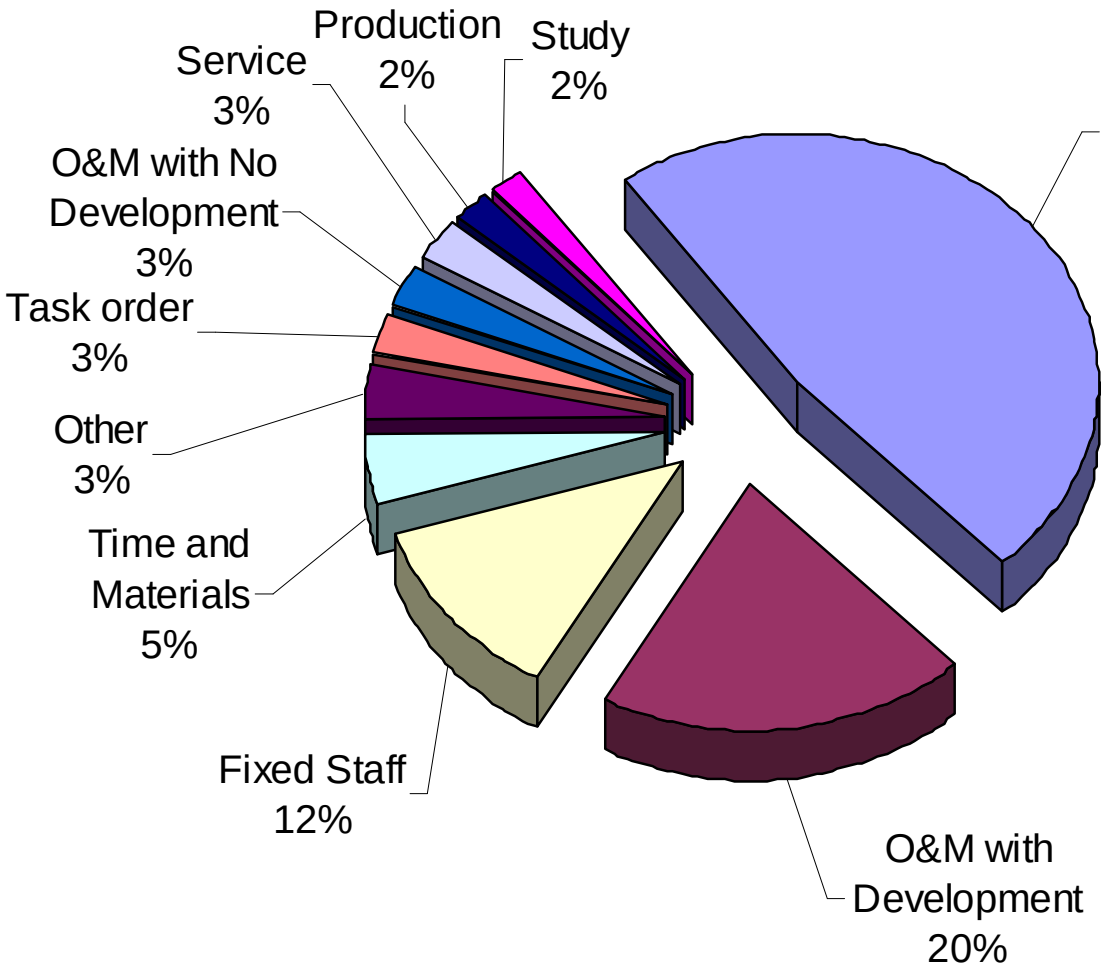


Gate 5: Program Startup Review **Gate 9: Test/Ship Readiness**

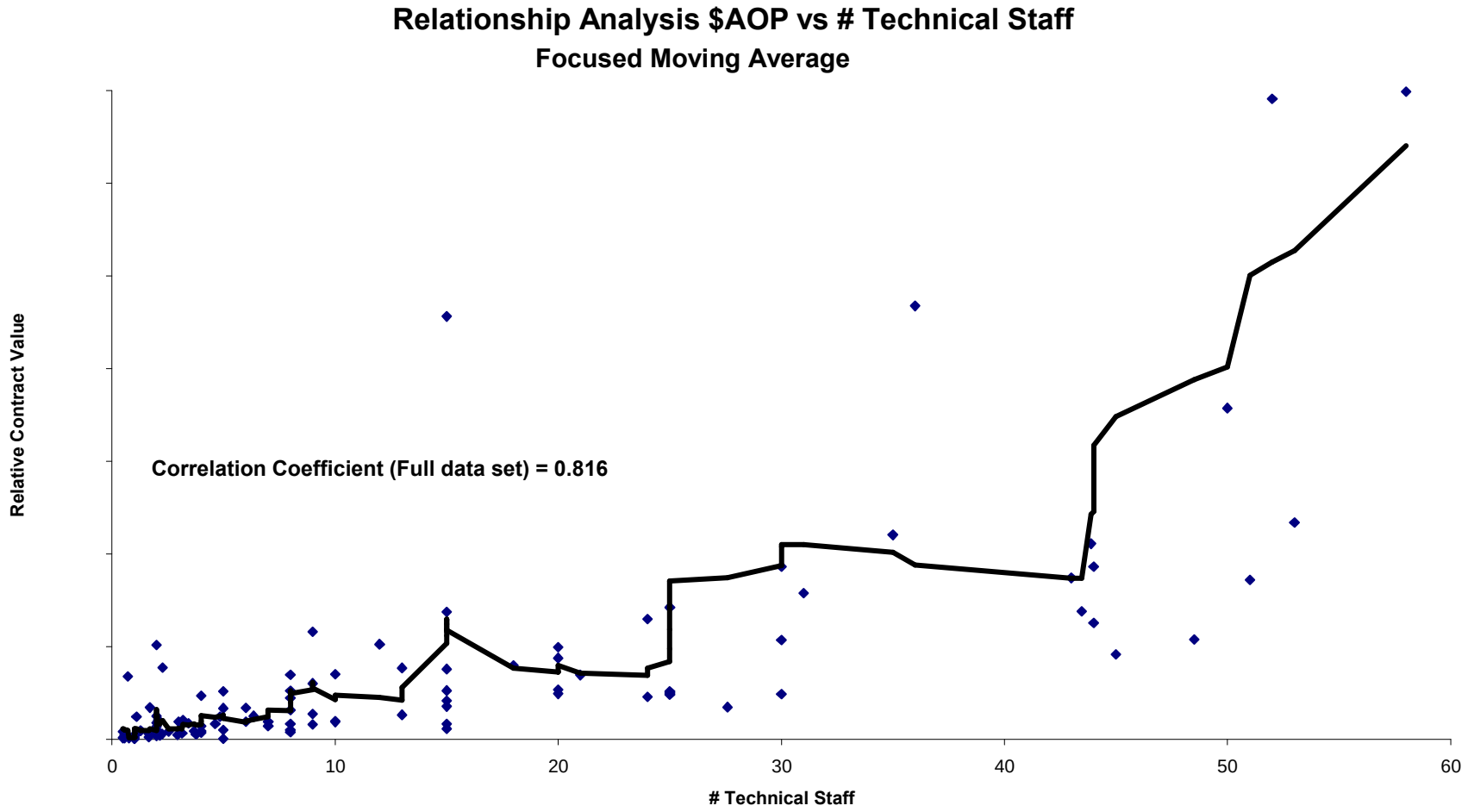
The 2-hump histogram is an artifact of predominant spiral developments.

Factors Analysis Example: ypes



	On-site	Off-site
Dev	40.27%	7.38%
O&M Dev	15.44%	4.70%
Fixed Staff	2.01%	10.07%
Other	2.01%	1.34%
Task order	2.68%	0.00%
T&M	3.36%	1.34%
O&M Non-Dev	0.00%	2.68%
Service	2.01%	0.67%
Production	2.01%	0.00%
Study	1.34%	0.67%
	71.14%	28.86%

Factors Analysis Example: e Analysis



Some correlation exists between # technical staff and $AOP, but not enough to allow us to exclude either the AOP or Technical Staff factor.

Key Factors Identified ms → 20 programs

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Key factors that were used to select the 20 Candidate Programs.

- **Multi-site (which sites)**
- **Program office location**
- **% on-site/off-site effort**
- **Program Type:**
  - Development
  - O&M with/follow-on to development
  - O&M not a follow-on to development
  - Service contract
  - Time and Materials
  - Fixed staff
  - Other
- **Appraisal Reuse basis:**
  - Has an existing objective evidence baseline
- **Program Scope: SE, SW, Subcontracts**
- **Contractual CMMI requirement**
- **Product Lines Covered: SS, NS, SIS, TIS, OTS**
- **Pre-acquisition/proposal program or Post-acquisition program**
- **Classification level and special restrictions**
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- **Projected engineering/technical staff in 9/2006.**
- **AOP Contract value in 2006.**

s Criteria → 14 programs

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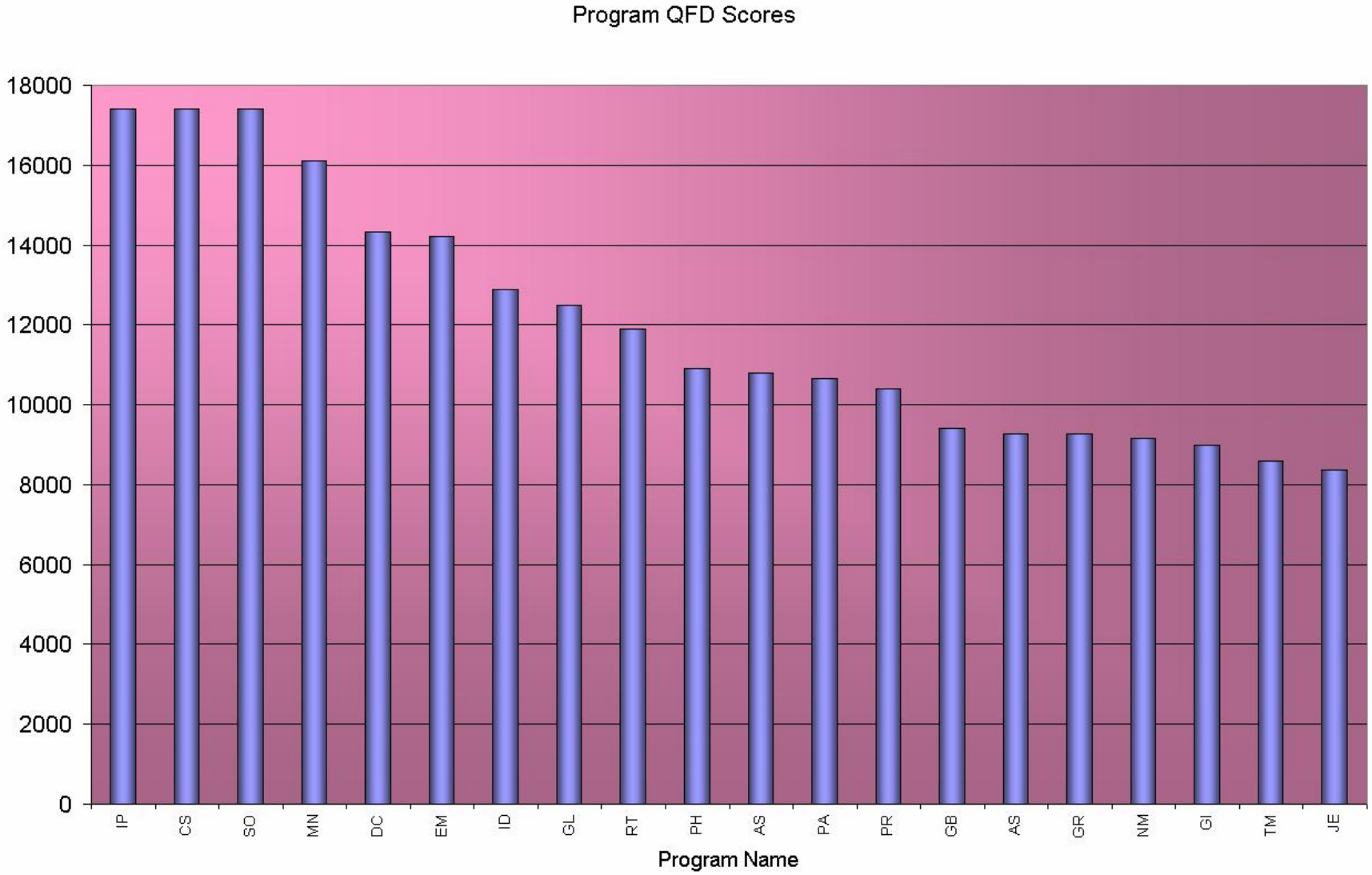
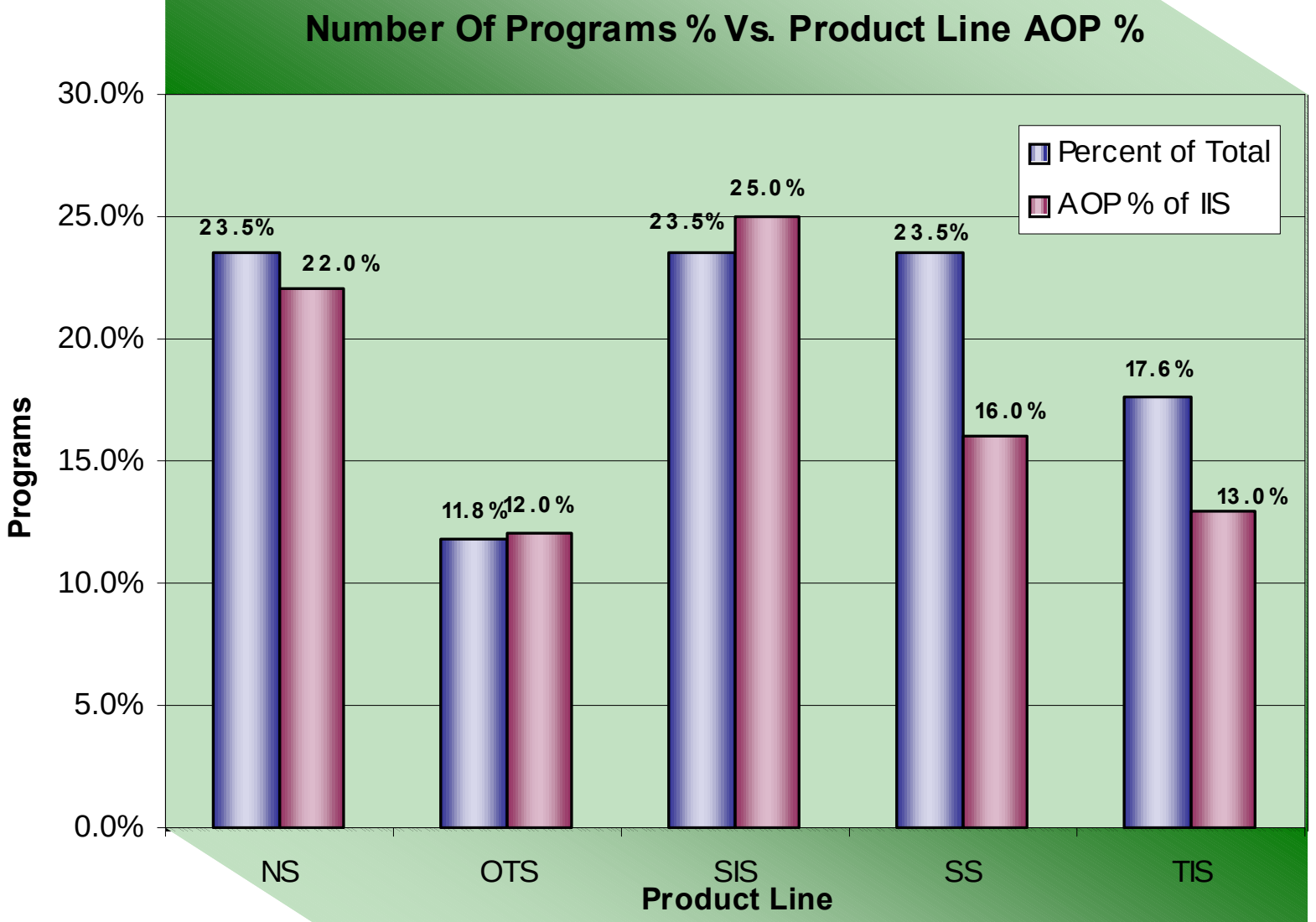
- Multi-site programs demonstrate we operate as an enterprise, not individual sites.
- Primary sites coverage demonstrates a majority of our work locations.
- Coverage of each Product Line ensures we include all our major customer groups.
- On-site programs present fewer logistics issues and ensure minimal impact to our customers.
- Larger development programs demonstrate our processes over a broader scope of the model than a study or short duration Time & Materials contract.
- Later lifecycle programs can demonstrate processes over a broader life-cycle scope.
- Programs with engineering development as well as subcontracts demonstrate our processes over a broader scope of the model.
- A contractual CMMI Program Requirement helps identify our commitment to our customers and our contractual obligations.
- Previous SCAMPI provides an OE refresh baseline to reduce risk against our aggressive schedule, and ID areas where more training and collection effort will be required.
- O&M in addition to on-going development demonstrate our processes over a broader scope of the model as well as commitment to maintain solid development processes.
- Larger programs better represent IIS against the 2006 AOP.

Pareto Diagram of Raw QFD Scores on the 20 programs





al Set: 5 Programs
many combinations analyzed)

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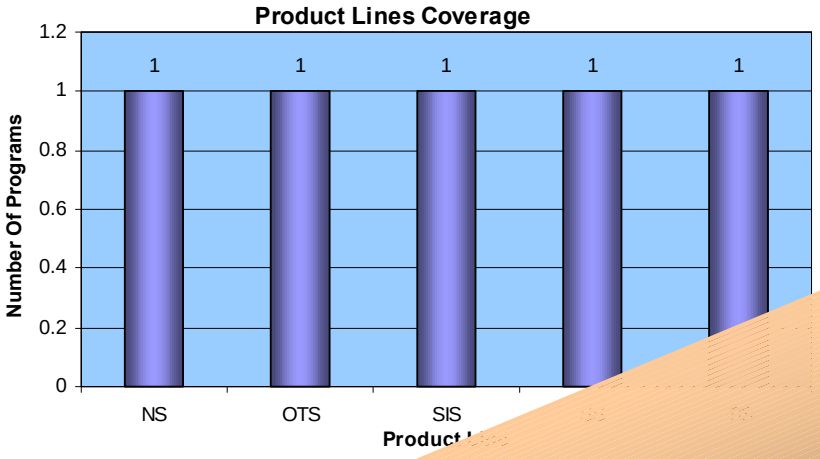
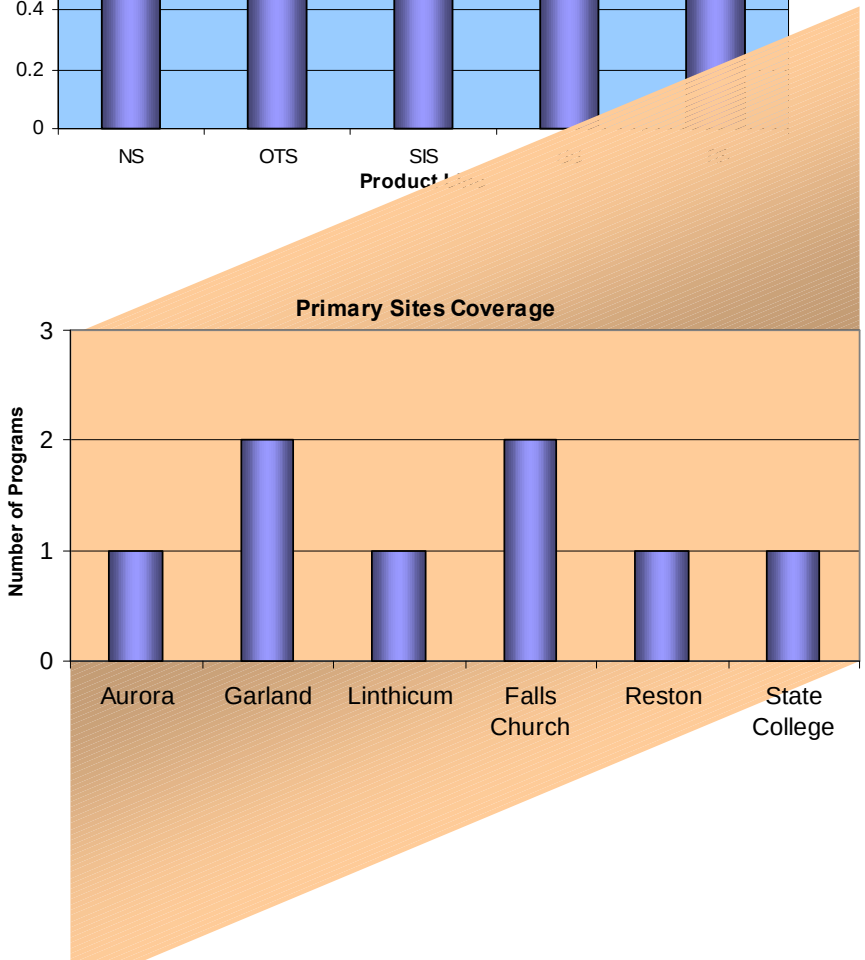
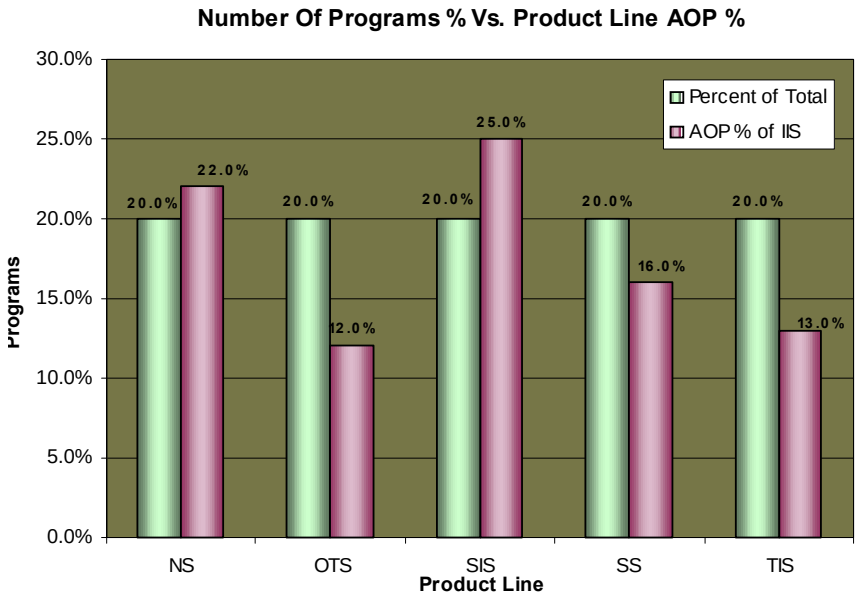




In our sample selection review, the appraisal team was able to make real-time changes to our recommendation, review the permutations against the Enterprise characteristics, and identify the programs be included in the final sample set.



ion: Site Allocation of IIS

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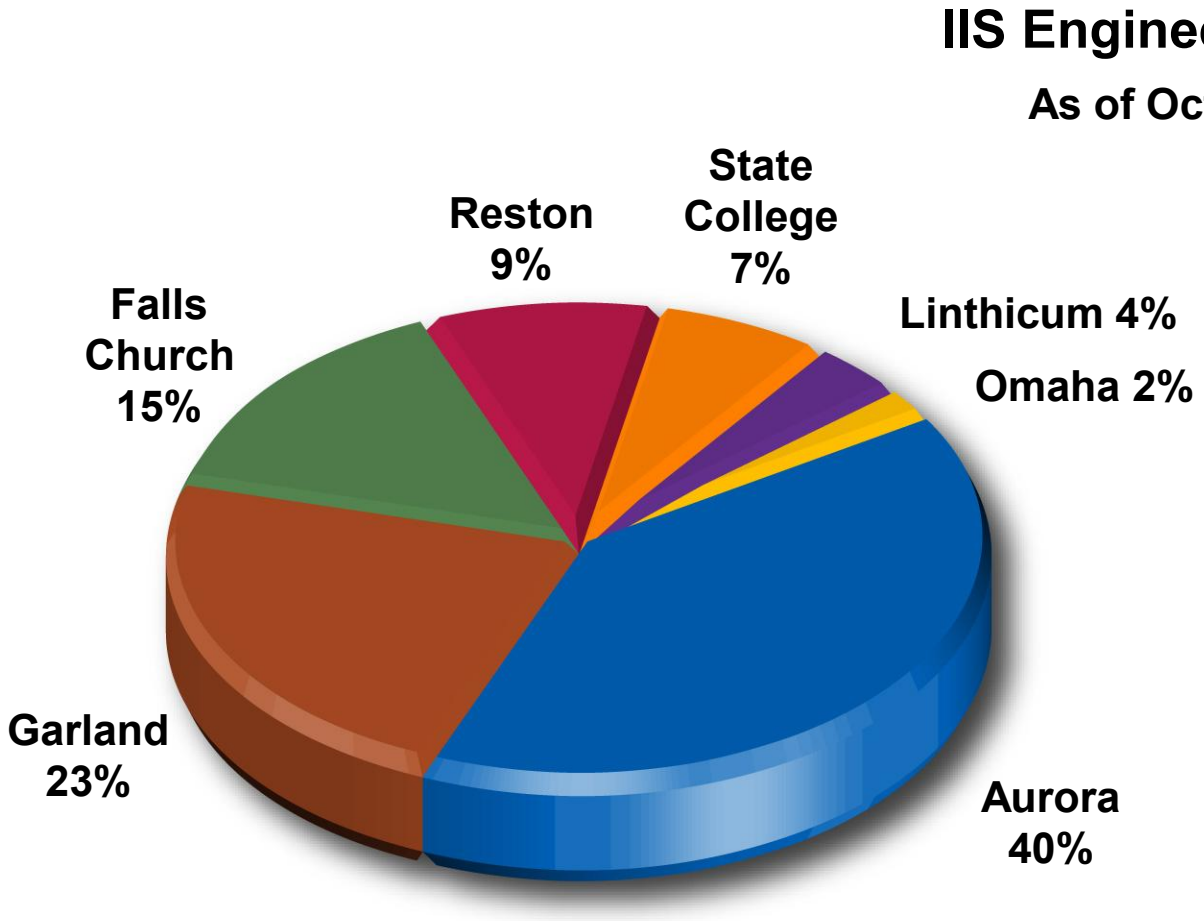

The largest percentage of the engineering population is located in Aurora….

...am Representative

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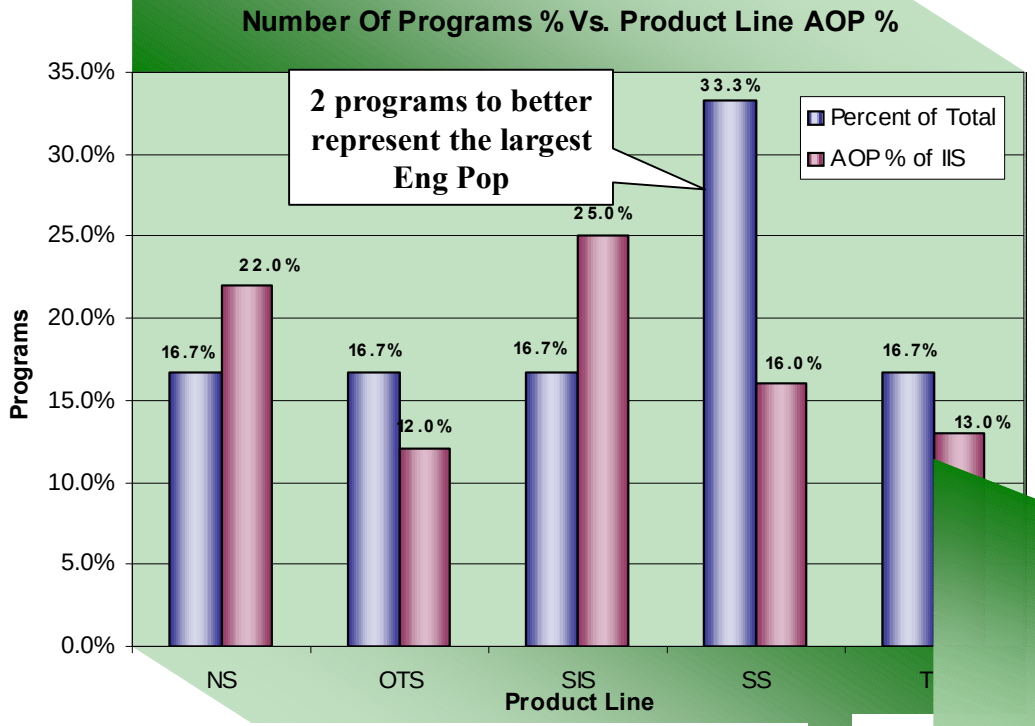
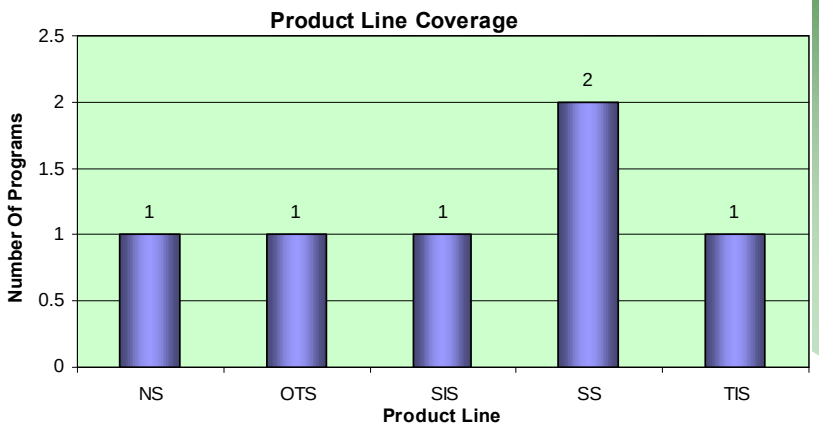
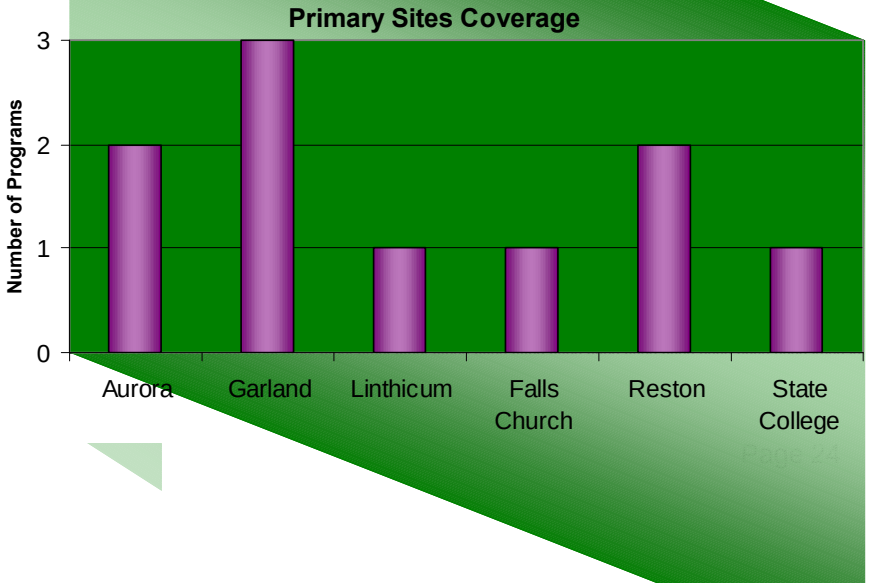


- NS: 1 program
- OTS: 1 program
- SIS: 1 program
- SS: 2 programs (larger engineering population)
- TIS: 1 program
- EPT: Enterprise Process ...nization





Benefits and Lessons Learned

nd Lessons Learned

- **Applying a solid process in your enterprise characterization and selection of a representative sample will allow you to:**
  - ï Meet the requirements of the MDD
  - ï Execute an enterprise appraisal against a reasonable representative sample
  - ï Maintain the integrity of the appraisal and confidence in the results.
- **Choosing wisely will take time.**
- **Using the DAR process area, the GP's, and your own internal best practices for decision making will help guide you though the enterprise characterization and selection process.**
- **Collecting and analyzing the program factors of the enterprise, and reviewing the results with the appraisal team will allow you to:**
  - ï Provide your appraiser with a deeper and broader understanding of the enterprise
  - ï Save time during the execution of the appraisal by reducing questions and issues related to how the enterprise operates.
- **Ensuring you have solid depth and breadth in an enterprise characterization and selection of your representative sample will make it easier to complete the ADS v1.2 – you will have the data on-hand.**