Comparing Cloud Costs Equitably - Overview

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Issue, Goal, Approach

- **Issue?** The cloud computing industry is changing the way government agencies deploy IT assets and has created a new area of acquisition specialty. To fill a knowledge gap in cloud computing cost estimating, Cloud Service Providers (CSPs) created numerous, easy-to-use tools and online cost calculators so users can quickly estimate costs with minimal data inputs. However, these tools can be misleading and it is difficult to compare cost estimates from these tools on an apples-to-apples basis.

  – Difficult to distinguish between a vendor's marketing tool and a useful cloud cost calculator

  – Over simplification of the tools may leave out significant hidden costs

  – Commercial vendors optional and customizable services offerings can greatly impact price

  – Different vendor cost estimating tools may include or exclude different cost elements

  – Variations in pricing structures create different cost drivers between vendors

- **Goal?** Enable analysts to knowledgably compare cloud solutions/service providers by identifying similarities, differences, and "gotchas" across prevalent service provider price lists, cost calculators, and rate cards.

- **Approach?** Compare offerings and pricing of multiple government and CSPs.

  – Leverage MITRE's cloud experience, identify stages of pricing, determine areas for focus with each stage

  – Build vignettes that explore the stages of pricing, using service provider calculators and highlighting the ranges of costs based on user inputs. Identify pricing "gotchas" (e.g., add-on costs not included in initial price quotes)
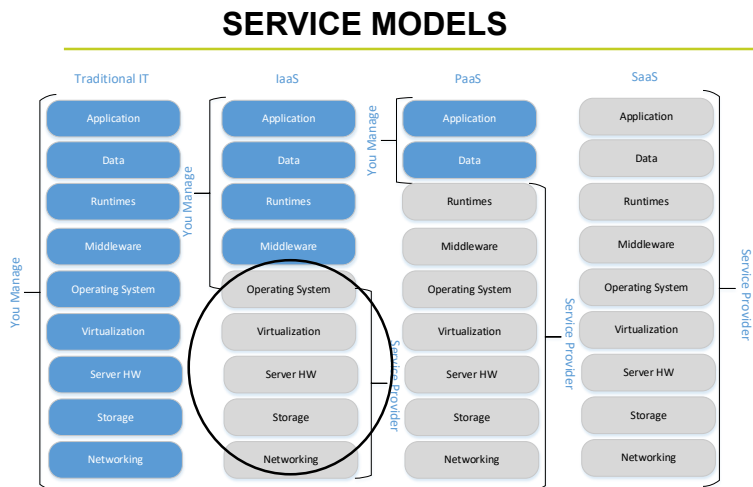
Quick may not be accurate

The available tools are only as good as the user's knowledge and the data available
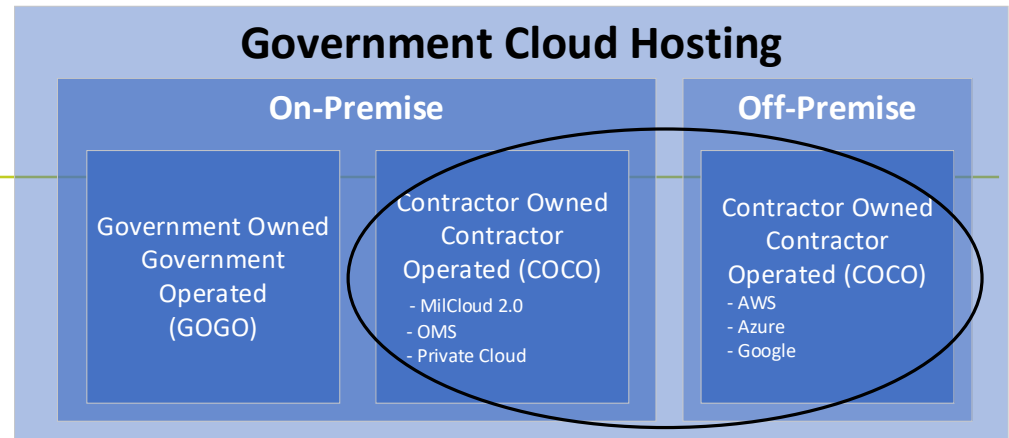
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BLUF

- **Available online calculators can be accurate, but only if the user possesses the right knowledge of cost elements included in each calculator, considerations of differences between vendors offerings and detailed application data**

- **Big differences exist in service offerings and pricing strategy between the group of commercial vs govt CSPs**
  - Commercial CSPs offer price discounts for length of commitment and overall size of deployment. Govt CSPs do not appear to offer any discounts.
  - Govt CSPs typically provide smaller number of services, fewer performance levels and less customization than commercials CSPs. This results in a less complex pricing structure and fewer cost considerations.
  - Commercial CSPs offer various classes of prepackaged VMs of different size, power, operating system (OS), bandwidth and storage type allow users to find predesigned, tailored VMs that match the application requirements.
  - Commercial CSPs offer different options and more options for licenses (BYOL, Open Source, Marketplace, Managed PaaS offerings etc.). These options have different impact on licensing costs and organic labor (labor cost not included in cost calculators). Govt CSPs typically require customer to acquire and sustain the licenses.

- **There are hundreds of different options and performance levels to select in cost calculators that will impact price**
  - All CSPs offer many different storage types, speed, and performance with a wide range of prices
    - AWS storage price range – S3 IOPS SSD $0.15+/GB month to Glacier Storage - $0.006/GB month
  - Difficult to make a comparison when not all options provide the service *(e.g., cache memory)*
  - Different levels of service and management responsibility must be accounted for

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Scope of Study

DEPLOYMENT MODELS

SERVICE MODELS

Government Cloud Hosting

On-Premise		Off-Premise
Government Owned Government Operated (GOGO)	Contractor Owned Contractor Operated (COCO) - MilCloud 2.0 - OMS - Private Cloud	Contractor Owned Contractor Operated (COCO) - AWS - Azure - Google

Business Models for Government Cloud Solutions

Traditional IT	IaaS	PaaS	SaaS
Application	Application	Application	Application
Data	Data	Data	Data
Runtimes	Runtimes	Runtimes	Runtimes
Middleware	Middleware	Middleware	Middleware
Operating System	Operating System	Operating System	Operating System
Virtualization	Virtualization	Virtualization	Virtualization
Server HW	Server HW	Server HW	Server HW
Storage	Storage	Storage	Storage
Networking	Networking	Networking	Networking

National Institute of Standards & Technology (NIST) Special Publication (SP) 800-145 Definition of Cloud Computing

Scope of Analysis

Cost calculators do not capture all costs elements or impacts

- **Out of Scope - Migration Costs**

  – Cost to move applications to each environment may differ substantially; cost not included in most cloud cost calculator

- **Out of Scope - Re-engineering application to take fully take advantage of the cloud**

  – Move away from lift and shift to reduce license and service costs

  – Leverage cloud native services (identify management, content delivery, dev and test tools, etc.)

- **Out of Scope - Services that right-size applications and dynamic scaling of environments in the cloud**

  – Most commercial vendors offer free or fee based services to help customer optimize the cost of their application based on actual usage

  – Burstable VMs; autoscaling

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Online Cost Calculators are Dangerous (1 of 2)

- **What does a sponsor application cost in Amazon Web Services (AWS) Cloud?**

  a. $1083.48/month

  b. $950.77/month

  c. $648.88/month

  d. $536.28/month

  e. $2,232.36/month

	Qty	Cores	RAM	OS
VM 1	3	1	1	Linux
VM 2	3	1	2	Linux
VM 3	3	2	4	Linux
DB 1	1	1	1	MySQL
DB 2	1	1	1	MYSQL
DB 3	1	2	4	MYSQL
DB 4	1	2	8	MYSQL

Storage	Size (Gb)	Type
General Purpose Storage	144	SSD
Database Storage	555	SSD
Backup (SnapShot)	54.5	Archive

Sponsor Application Profile gathered from actual AWS Bill

- **All the above costs came from the <u>same basic requirements</u> being input to an AWS Simple Monthly Calculator***

  – Only minor changes to options (e.g., Reserved vs On Demand; Single Region** vs Multi Region Availability; General SSD vs IOPS Provisioned)

  – Two of the estimates did not include the add on background services

VM = Virtual Machine
DB = Data Base
SSD = Solid State Drive
IOPS = Input/Output Operations Per Second
*https://calculator.s3.amazonaws.com/index.html as of Aug 2018
** A "region" represents a geographic area uniquely defined by a given commercial Cloud Service Provider (CSP)

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Online Cost Calculators are Dangerous (2 of 2)

Range of AWS's Simple Monthly Cost Calculator for an application

	Actual Cost	Actual Cost w/ Reserved Instances	Basic Estimate - On Demand	Basic Estimate Reserved Instances	Complete Multizone with IOPS SSDs
VMs	$ 205.60	$ 154.04	$ 205.60	$ 154.04	$ 205.60
General Storage	$ 17.28	$ 17.28	$ 17.28	$ 17.28	$ 17.28
DB VMs	$ 356.40	$ 275.25	$ 356.40	$ 295.36	$ 414.32
DB Storage	$ 138.69	$ 138.69	$ 66.00	$ 66.00	$ 1,126.50
Backup - Snapshots	$ 3.60	$ 3.60	$ 3.60	$ 3.60	$ 3.60
Elastic Cache	$ 91.44	$ 91.44	Not Included	Not Included	$ 91.44
Load Balancers	$ 138.24	$ 138.24	Not Included	Not Included	$ 138.24
Data Transfer	$ 25.52	$ 25.52	Not Included	Not Included	$ 25.52
Misc.	$ 6.71	$ 6.71	Not Included	Not Included	$ 6.71
Business Support	$ 100.00	$ 100.00	Not Included	Not Included	$ 203.15
Total	**$ 1,083.48**	**$ 950.77**	**$ 648.88**	**$ 536.28**	**$ 2,232.36**
Price Difference		**-12.2%**	**-40.1%**	**-50.5%**	**106.0%**

- **In the table above, each cost beyond the "Basic Estimate" is complete, correct, and valid for specific and reasonably expected circumstances**
  - The customer should run reserved instances because the data showed the apps were on 24x7 (assume the application runs throughout the year)
  - Database applications often require high IOPS; the customer was running a few virtual machines in a multi-regional setting already
- **The Basic Estimates are often provided/applied because a lack of time and/or an understanding of the technical details**
  - We only knew the details because the bill showed that they needed 6 Load balancers, 2 Elastic Cache Nodes, and 163GB of data transferred

https://calculator.s3.amazonaws.com/index.html *as of Aug 2018*

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Cloud Service Provider (CSP) Variances of Services

- **Key differences of between the 6 CSPs services and pricing:**

	AWS	Azure	Google
Compute			
Compute Resources	Hundreds of VM Packages with or without limited storage and OS - provide application specific optimization - Can bring own OS, use AWS OS or open source OS - Price breaks for commitments to length of contract for reserved instances (published rates) and number of reserved instances (not published)	Hundreds of VM Packages with or without limited storage and OS - provide application specific optimization - Can bring own OS, use Microsoft OS or open source OS - Price breaks for commitments to length of contract for reserved instances (published rates) and number of reserved instances (not published)	Hundreds of VM Packages with or without limited storage and OS - provide application specific optimization - Can bring own OS, use Google provided OS (note fewer options for OS available) - Price breaks for commitments to length of contract for reserved instances (published rates) and also provides automatic price breaks for "sustained use"
VM Backups	Captured in Snapshots - Charged storage rate based on size of data - no cost for backup licenses - need to estimate data for backup	Captured in Snapshots - Charged storage rate based on size of data - no cost for backup licenses - need to estimate data for backup	Captured in Snapshots - Charged storage rate based on size of data - no cost for backup licenses - need to estimate data for backup
Cache Memory	Elastic Cache Service - Chargers per node per month. Nodes vary in size. Can be a significant part of the monthly bill	Elastic Cache Service - Chargers per node per month. Nodes vary in size. Can be a significant part of the monthly bill	Offers 3rd party cloud Cache memory service through Redis Enterprise. Pricing is not publicly available; need to contact Redis Sales Associate with requirements to obtain
Load Balancers	Three type of Load balancers offered Application Based; Network Based; Classic Load Balancer	Load balancers are offered based on a monthly rate per load balancer with an additional charge for the data processed (which appears to be minimal $0.005 /GB)	Load balancers are offered based on a monthly rate per the number of rules (base charge comes with 5 rules)
Patch Management OS	Tools for centralized patch management included in the resource costs	Centralized Patch Management can be run through Azure Automation for a fee	Does not appear to be a centralized tool
Storage			
Block Storage	• EBS General Purpose SSD -$0.12 per GB-month • Amazon EBS Provisioned IOPS SSD - $0.15 per GB-month + $0.078 per IOPS-month • Amazon EBS HDD - $0.054 per GB-month • Amazon EBS Cold HDD - $0.03 per GB-month	Managed Disks - In whole disk increments Premium (SSD) - $0.11 to $0.15 per GB month Standard HDD - $0.040 to $0.048 per GB month	Managed Disks - In whole disk increments Standard provisioned - $0.044 SSD provisioned - $0.187 Regional standard provisioned - $0.088 Regional SSD provisioned - (Beta) $0.260 Snapshot storage $0.029 IO operations No additional charge

Partial view of Comparison Table

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Challenges and Considerations

Challenges

- **Reserved Instances vs On Demand**
  - On Demand Pricing allows customer to turn off and stop paying for Virtual Machines (VMs)
  - Reserved Instances provide lower rates for guaranteed use with greater discount for paying upfront
- **Hidden costs require detailed information**
  - Transfer out costs, load balancers, licensing costs
- **Application (app)-specific VM options**
  - Commercial service providers (CSPs) offer specialized VMs optimized for different app types and prices can vary widely
- **Storage types**
  - Most CSPs offer different types of storage based on latency, frequency of access, and type of data stored with a wide range of prices between services
  - Storage performance and prices also vary considerably between the different CSP (e.g. A performance storage level of one vendor might not provide the same IOPS of another).

Considerations

- **Information Impact Level (IIL)**
  - CSPs often charge more for higher IIL zones
  - AWS only CSP certified for IIL-6 classified data hosting. Azure, MilCloud 2.0 and OMS currently certified to IIL-5.
- **Detailed technical evals is key to pricing**
  - Accurate prices require more information in additional to the number of VMs, Central Processing Unit (CPU), cores, Random-Access Memory (RAM) and Gigabytes (GB) of Storage
- **Work with a CSP representative and with customer technical engineers**
  - Correctly apply services/rates
  - Analyze trades between different services and architectures
  - Guidance on services that optimize the fulfilment of requirements and minimize cost
  - Insight on new services and pricing

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Summary of CSP Discoveries

CSP	DESCRIPTION	COST CONSIDERATIONS	REFERENCE
AWS	Started cloud services in 2006*	Different prices for different Information Impact Levels	*https://aws.amazon.com/10year/
	30% of the cloud infrastructure services market**	Storage needs	
	Offers IaaS, PaaS and SaaS on the commercial market	Rates for Commercial and GovCloud Region	**https://www.cnbc.com/2018/04/27/microsoft-gains-cloud-market-share-in-q1-but-aws-still-dominates.html
	SaaS not available to DoD GovCloud customers at this time	Unpublished rates for Amazon Secret Region	
	Billing in second(s) increments		
	Certified up to IIL-6		
MICROSOFT AZURE	Started cloud services in 2008*	Different prices for different Information Impact Levels	*https://www.cnet.com/news/microsoft-launches-windows-azure/
	13% of the cloud infrastructure services market**	Reserved VM rates not published for their government cloud offering	
	Offers IaaS, PaaS and Limited SaaS on the commercial market		**https://www.cnbc.com/2018/04/27/microsoft-gains-cloud-market-share-in-q1-but-aws-still-dominates.html
	Only SaaS offering is Office 365		
	Billing in round down to nearest minute Increments		
	Certified up to IIL-5; seeking IIL-6 by the end of the 2019 calendar year		
GOOGLE CLOUD	Started cloud IaaS services in 2010*	Different prices for different Information Impact Levels	*https://www.datamation.com/cloud-computing/google-cloud-platform.html
	6% of the cloud infrastructure services market**	Unique discount structure (automatically applied after achieving a threshold of runtime per month)	
	Offers IaaS, PaaS and limited SaaS on the commercial market		**https://www.cnbc.com/2018/04/27/microsoft-gains-cloud-market-share-in-q1-but-aws-still-dominates.html
	Billing in second(s) increments		
	Certified up to IIL-2; seeking IIL-5		
milCloud 2.0	Started pilot cloud services in 2018	No price discounts for size or length of contract	https://www.disa.mil/-/media/Files/DISA/News/Events/Symposium/milCloud-2-0-May-2018.ashx?la=en&hash=01F92057AA7F936FF7058108C02563936F199A01
	DISA-managed program	Fewer options that impact prices	
	Billing down to hour	Requires least information to price	
	Offering IaaS and operating system portion of PaaS	Simpler costs structure	
Onsite Managed Services (OMS)	Contractor operated cloud solution, located in government data center	Bundled VM pricing, with additional charges to customize	https://www.smartronix.com/services/Cloud-Computing/Documents/SMX_ServiceSlick_CloudSrvDoD.pdf
	Designed to host IIL4/5 Non-classified Internet Protocol (IP) Router Network (NIPRNET) workloads	Additional fees for contract charges, and DoD facility charges	
	Eventually IIL-6 through Secure IP Router Network (SIPRNET)	Different storage types, and backup options	
	Billing in 5 minute increments		
COMMERCIAL PRIVATE CLOUD (COCO-ON)	Private cloud physically located on a government installation	Monthly only billing	
	Power, cooling, floor space, connectivity, physical access provided to contractor	Basis of pricing (e.g., complexity-based vs by core/VM/storage/RAM)	
	Equipment & hosting software contractor owned		
	Service contract, not a lease		
	IIL-5 certified		

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AWS

CSP Highlight

- **Started cloud services in 2006***

- **30% of the cloud infrastructure services market****

- **Offers IaaS, PaaS and SaaS on the commercial market**

- **SaaS not available to DoD GovCloud customers at this time**

- **Certified up to IIL-6**

- **Cost considerations**

  - Information Impact Level

  - Storage needs

  - Rates for Commercial and GovCloud Region

  - Unpublished rates for Amazon Secret Region

Select Billing Option

Instance Type: t2.small
Operating System: Windows
Usage: 160 Hours/Month

Per Instance Prices & Projected Costs (all in USD)

Select	Name	Upfront Price	Effective Hourly Cost	Effective Monthly Cost	1 Year Cost	3 Year Cost
○	On-Demand (No Contract)	---	0.032	5.12	61.44	184.32
○	1 Yr No Upfront Reserved	0.00	0.024	17.23	206.74	620.21
○	1 Yr Partial Upfront Reserved	100.00	0.023	16.66	199.87	599.60
●	1 Yr All Upfront Reserved	198.00	0.023	16.50	198.00	594.00
○	3 Yr No Upfront Reserved	0.00	0.019	14.02	---	504.58
○	3 Yr Partial Upfront Reserved	221.00	0.017	12.71	---	457.52
○	3 Yr All Upfront Reserved	430.00	0.016	11.95	---	430.00
○	1 Yr No Upfront Convertible	0.00	0.026	18.77	225.14	675.40
○	1 Yr Partial Upfront Convertible	109.00	0.025	18.21	218.50	655.50
○	1 Yr All Upfront Convertible	216.00	0.025	18.00	216.00	648.00
○	3 Yr No Upfront Convertible	0.00	0.021	15.12	---	544.00
○	3 Yr Partial Upfront Convertible	261.00	0.020	14.48	---	521.18
○	3 Yr All Upfront Convertible	517.00	0.020	14.37	---	517.00

https://calculator.s3.amazonaws.com/index.html   Close

Services	**Estimate of your Monthly Bill ($ 1.95)**

Below you will see an estimate of your monthly bill. To remove the service from the estimate, jump back to the service and clear the specific serv...
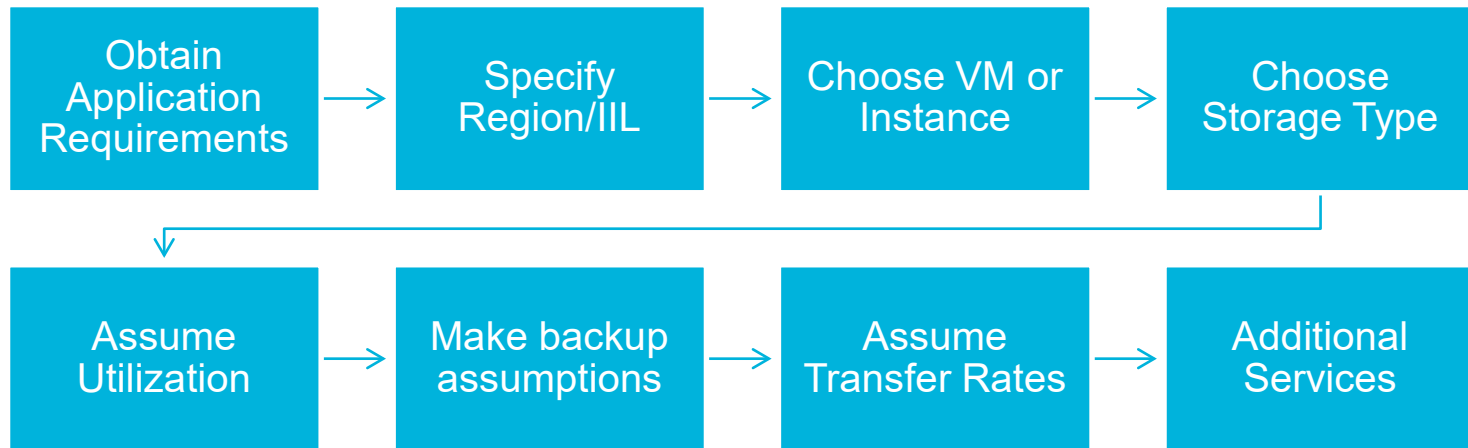
Export to CSV			Save and Share
⊟ Amazon EC2 Service (AWS GovCloud (US))			$ 237.00
Compute:		$ 0.00	
Reserved Instances (One-time Fee):		$ 237.00	
⊟ Amazon S3 Service (AWS GovCloud (US))			$ 1.95
S3 Standard Storage:		$ 1.95	
⊞ AWS Support (Basic)			$ 0.00
Total One-Time Payment:			$ 237.00
Total Monthly Payment:			$ 1.95

https://calculator.s3.amazonaws.com/index.html

*https://aws.amazon.com/10year/
**https://www.cnbc.com/2018/04/27/microsoft-gains-cloud-market-share-in-q1-but-aws-still-dominates.html

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Stages of Pricing

"Gotchas" may exist at each pricing stage.

Obtain Application Requirements	→	Specify Region/IIL	→	Choose VM or Instance	→	Choose Storage Type

Assume Utilization	→	Make backup assumptions	→	Assume Transfer Rates	→	Additional Services

- The 'Stages of Pricing' provides a service provider agnostic view of the different areas that impact cloud cost
  - Differences in the service offerings and pricing schemes across the service providers become evident at increasing levels of granularity within these stages
- This defines a process that can be followed to create a cloud cost estimate, ensuring the major price components are addressed
  - Service provider specific calculators or tools may differ slightly in the ordering of stages; in some instances, service provider quotes do not even address some of these stages
  - Each stage may also include multiple service provider-dependent decisions that affect the output
- Vignettes will highlight one or two stages of pricing, and identify potential pitfalls that could be overlooked when developing a hosting cost estimate

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Stages of Pricing

Summary of "Gotchas" and Questions

Stage	Gotchas	Questions to Ask
OBTAIN APPLICATION REQUIREMENTS		
	• Changing or poorly understood requirements	• Cloud architecture exist? Apps/data identified? Data to migrate known?
	• Scoping issues, e.g. fluctuating demand for services	• Can cloud resources be determined, e.g. VMs, cores, RAM, storage?
SPECIFY REGION/INFORMATION IMPACT LEVEL (IIL)		
	• Services priced at wrong IIL; region not certified for data needs	• Apps require availability across multiple regions to decrease latency?
	• Vendor regional construct unclear/misunderstood	• Data at what IIL? # regions needed for COOP? Which regions can host?
CHOOSE VM OR INSTANCE		
	• Limited set of VMs in a specific configuration of vCPU and memory	• Considerations that could affect VM selection include:
	• Often, multiple VMs could satisfy a given set of application requirements	○ How variable is the workload?
	• VMs designed for specific functionality; cost/performance may differ	○ Processor clock speed and b/w required for compute heavy apps?
CHOOSE STORAGE TYPE		
	• Accurate storage sizing is crucial; NOT all storage is the same	• Storage block- or object-based? Storage tier for performance?
	• For an access fee, cheaper archive options exist if data rarely accessed	• How often data accessed? Storage retention? Need redundancy?
ASSUME UTILIZATION		
	• Hrs utilized under/over estimated	• How long will the VMs be running, e.g., # business hrs vs continuous?
	• Storage needs may increase; back-ups/"snapshots" add storage	• How backups and archiving done? Storage needs change with time?
MAKE BACKUP ASSUMPTIONS		
	• Storage type, size, and transfer requirements poorly planned	• Back-up needed when and where?
	• Not understanding the COOP plan	• COOP and replication requirements?
ASSUME TRANSFER RATES		
	• Service providers typically charge for xfer out based on GB data transferred	• Expected data transfer out rate in GB/Month for the app?
	• Possible fees for data xfer inter-region	• Qty data xfer inter-region and deployed intra-region to multi zones?
	○ Fees may be inccured for Intra-region xfers but at a lower rate	• Multiple prices for data transfer, depending on max speed?
ADDITIONAL SERVICES		
	• Business and enterprise support needs	• What support is required or needs to be part of the cost estimate?
	○ Pricing structure, services provided, and support tiers may differ	• Does the service provider offer the service and at what level?
	• Beyond basic compute/storage, e.g. load balancers, cache memory	○ Can price be negotiated for different/more service needs?

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Vignettes

- **Vignettes illustrate example systems and explore the possible ranges of cost by CSP based on differing assumptions**
  - These will highlight the cost areas that require technical input in order to generate 'apples to apples' estimates
  - Some CSPs were eliminated from a vignette based on not being able to offer the service (e.g. Google is not currently certified to host IIL3-6 workloads)
- **Vignettes:**
  1. Reserved instances and IIL-2
     - Costing a small workload at IIL-2
     - 360hrs per month
  2. IIL 4 application with multiple regions
     - Costing a medium workload at IIL-4
     - World wide operations
  3. IIL 5 application with archived storage
     - An enterprise resource planning (ERP) system at IIL-5
     - Hot – hot backup
  4. IIL 6 application
     - Medium workload
     - IIL-6
  5. Basic inputs vs additional resources
     - Omission or slight changes to the selections in the online calculators can decrease prices by more than 50% or increase prices by more than 100%
     - Customers can potentially save 20% or so if they want to select Reserved Instances compared to running On Demand Instance 24x7

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Summary of Vignettes

Vignette	Areas of Uncertainty	Questions to Ask	Price Range
1 Small VM 50 GB Storage Reserved Instances IIL-2	• Using on demand rates, save on monthly bills by turning off apps that are not being used • Reserved instances offer fixed annual rates with a lower effective rate for minimum commitments • Short-lived apps	• Run time of the app? • Procedures to turn off the app when not in use? • App persists throughout the year?	$20 to $103 per month
4 VMs - 6TB Storage IIL-4 app Multiple Regions	• Types of VM selected: Hyperscale CSPs offer limited set of VMs in specific configuration. Multiple VM types may satisfy requirements. • Multiple regions: If app is deployed in multiple regions, CSP data center location may limit options. Typically, a cost for data transfer across regions.	• VM type: Intended purpose of the app? • Multi-regional zone vs single zone availability: App require availability across multiple regions to decrease latency? Each CSP may offer this capability with different solution sets. How do CSPs charge for transferring data across regions?	$1100 to $3200 per month
4 VMs - 46TB Storage IIL-5 app with Archived Storage	• IIL: CSPs may charge different rates for different IILs. • COOP: Restoration and backup options within the data center, within a region, and across regions? Costs may double for fully running backup in another region. • Archived storage: Agencies may require data to be stored according to regulation	• IIL: Information Impact Level (IIL) required? • COOP: What level of failover needed? How quickly can app or data be back on line after event? • Archieve Storage: How often will data be accessed? How long will data be stored? Options for CSPs to store this type of data?	$2000 to $4400 per month
4 VMs - 6TB Storage IIL-6 app	Rates for higher IIL-levels are not published	• Can the service provider host data at IIL-6? Only AWS is currently certified to host at IIL 6 • What rates apply for IIL-6 data?	AWS only
13 VMs - 700 GB Storage Basic Inputs vs Additional Resources	• Apps can require additional resources when low latency and high performance are required • Load Balancers: Most CSPs offer comparable services at similar price points. • Cached Memory: CSPs offer service but prices differ substantially. • Multizone and High Availability: CSPs offer options for this service but can drastically increase costs.	• Load balancers: App require load balancers to spread demand across VMs? Each CSP offer similar capabilities at the proper security level? • Cache memory: App require cached storage for low latency performance? Each CSP offer similar capabilities at the proper security level? • Multi-regional zones vs single zone availability: App require availability across zones to allow for failover/COOP? CSPs provide this capability with different solution sets.	$500 to $1700 per month

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Vignette 2 – IIL-4 Application with Multiple Regions

Application to Cost

| Basic Application Characteristics			
Security Level:	IL-4		
Region (single/multi)	Multizone		
Hours per Month:	24x7		
Compute	Cores	RAM (GB)	OS
VM 1	2	4	Windows
VM 2	2	4	Windows
VM 3	4	16	Windows
VM 4	4	16	Windows
Storage	Storage Type	Size (GB)	
Primary Storage	High IOPS	5000	
Backup (Snapshot)	SSD	1000	
Other (if applicable)			
Data Transfer	Yes	2500 GB/Mo	

Areas of Uncertainty

- **Types of VM selected**
  - Hyperscale cloud computing service providers typically offer a limited set of VMs in a specific configuration (fixed amount of vCPU and memory)
  - Many times, there are multiple VM types that could satisfy the requirements
- **Multiple regions**
  - If application is to be deployed in multiple regions, the location of CSP data centers may limit options
  - MilCloud 2.0, OMS and COCO On-Prem cannot satisfy this need
  - There is typically a cost for data transfer across regions

Questions to Ask

- **VM type**
  - What is the intended purpose of the application? Considerations that could affect VM selection include
    - How variable is the workload? Are there short bursts of high intensity computations?
    - If the application is compute intensive, is there a processor clock speed requirement?
    - Does the application have high bandwidth requirements?
- **Multi-regional zone versus single zone availability**
  - Does the application require availability across multiple regions to decrease latency?
  - Each service provider may offer this capability with different solution sets. How does each service provider offer that capability? If low latency is the end goal, does each solution set sufficiently meet the requirement?
  - How do service providers charge for transferring data across regions? How much data transfer will this application require?

Comparison of Cloud Costs with Ranges

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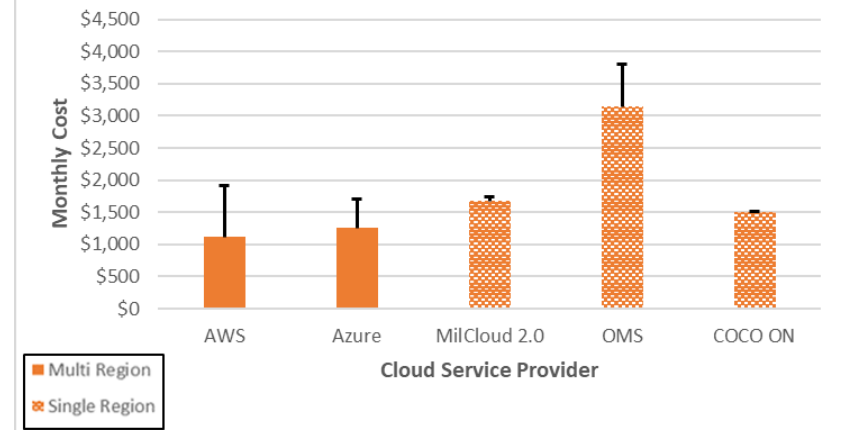
Conclusions

- **To create accurate and equitable comparisons, cost analyst should:**
  - Understand the difference between the costs included and excluded for each cost estimating tool or rate card
  - Consider the impact of the different options for commercial CSPs services, customization, pricing discounts and varying level of performance
  - Gather the required application data as identified in the stages of pricing
  - Include hidden costs
  - Evaluate the impact on labor and licensing costs

- **Commercial CSPs have similar strategies for service design and pricing; those strategies differ from those of government CSPs.**
  - Commercial CSPs offer a variety of prepackaged VMs of different size, power, bandwidth, operating system (OS) and storage type that allow users to quickly and easily selected VMs that are optimized for their application
    - Within the same vendor, similar sized VMs between the different groups can cost have a substantial price differnce
  - Commercial CSPs offer a wider range of services and performance levels
  - Commercial offers different options for licenses; operating system/database software

- **Not all services and performance levels are the same**
  - Options for different types of services and performance levels create cost uncertainty when comparing between vendors
  - Difficult to make a comparison when not all CSPs provide the service (e.g., cache memory)

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Back-Up

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Scope of Cloud Service Provider (CSP) Analysis

- **To understand the landscape of cloud solutions, investigated the services and pricing of 6 different service providers and their hosting costs**
  - AWS
  - Microsoft Azure
  - Google Cloud Platform
  - DISA milCloud 2.0
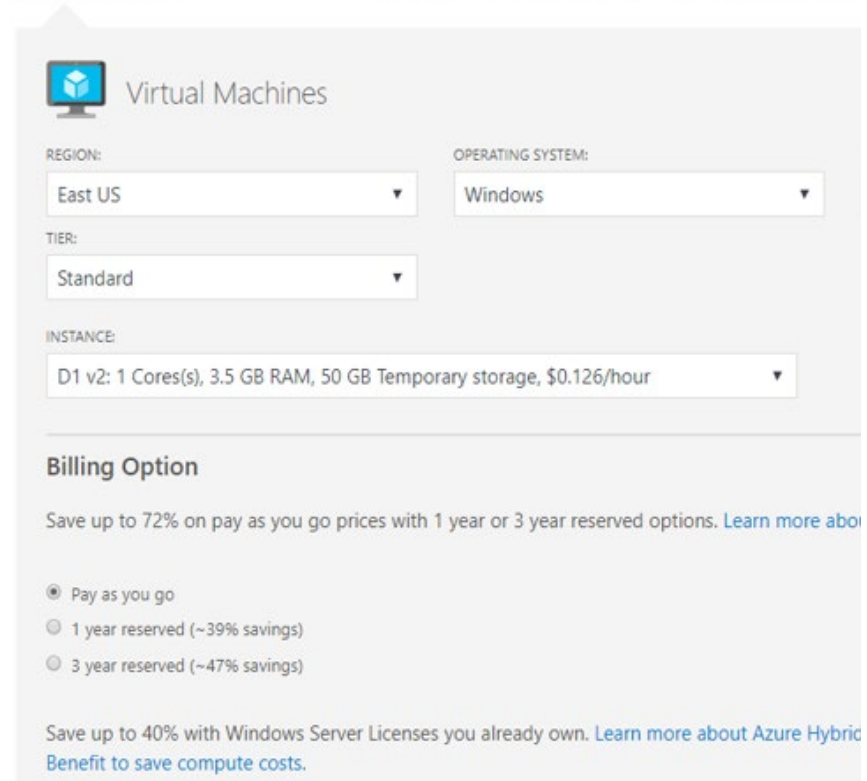 - On-Site Managed Services OMS
  - COCO-ON

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Microsoft Azure

- **Started cloud services in 2008***

- **13% of the cloud infrastructure services market****

- **Offers IaaS, PaaS and Limited SaaS on the commercial market**

- **Only SaaS offering is Office 365**

- **Certified up to IIL-5; seeking IIL-6 by the end of the calendar year**

- **Cost considerations**

  - Information Impact Level

  - Reserved VM rates not published for their government cloud offering

Your Estimate

Virtual Machines   1 D1 v2 (1 vCPU(s), 3.5 GB RAM) x 160 Hours

Virtual Machines

REGION:
East US

OPERATING SYSTEM:
Windows

TIER:
Standard

INSTANCE:
D1 v2: 1 Cores(s), 3.5 GB RAM, 50 GB Temporary storage, $0.126/hour

Billing Option

Save up to 72% on pay as you go prices with 1 year or 3 year reserved options. Learn more abou

- Pay as you go
- 1 year reserved (~39% savings)
- 3 year reserved (~47% savings)

Save up to 40% with Windows Server Licenses you already own. Learn more about Azure Hybric Benefit to save compute costs.

https://azure.microsoft.com/en-us/pricing/calculator/

*https://www.cnet.com/news/microsoft-launches-windows-azure/
**https://www.cnbc.com/2018/04/27/microsoft-gains-cloud-market-share-in-q1-but-aws-still-dominates.html

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Google Cloud

- **Started cloud IaaS services in 2010***

- **6% of the cloud infrastructure services market****

- **Offers IaaS, PaaS and limited SaaS on the commercial market**

- **Certified up to IIL-2; seeking IIL-5**

- **Cost considerations**

  - Information Impact level

  - Unique discount structure

    - Automatically applied after achieving a threshold of runtime per month)

1 x Web page

160 total hours per month

VM class: regular

Instance type: n1-standard-1

Region: Los Angeles

Paid OS Cost: USD 13.44

GCE Instance Cost: USD 9.14

Estimated Component Cost: USD 22.58 per 1 month

Cloud Storage

Los Angeles

Regional storage: 50 GB

USD 1.15

https://cloud.google.com/products/calculator/

*https://www.datamation.com/cloud-computing/google-cloud-platform.html

**https://www.cnbc.com/2018/04/27/microsoft-gains-cloud-market-share-in-q1-but-aws-still-dominates.html

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MilCloud 2.0

- **Started pilot cloud services in 2018**

- **DISA-managed program**

- **Billing down to hour**

- **Offering IaaS and operating system portion of PaaS**

- **Cost considerations:**

  – No price discounts for size or length of contract

  – Fewer options that impact prices

    - Requires least information to price

  – Simpler costs structure

DISA Financial and Product Overview

UNCLASSIFIED

Workload Size	vCPU Example OS	Mem/GB Example OS	Hourly Rate
Micro VM	1	1	$0.046388
Small	1	2	$0.049663
Medium	2	4	$0.073119
Large	4	8	$0.120031
Extra-Large	8	16	$0.177688
XX-Large	16	32	$0.293001

Product	Description
Platform	Infrastructure as a Service, Software as a Service, Platform as a Service
Storage	Block Storage and Backup Services
Network	Routable IP and VPN
***Security	Patch management, Logging, and Vulnerability Management
Additional Services	Systems Administration, Application Rationalization, Agile Development, and Infrastructure Strategy Support

Storage	Rate
Tier 1 Block Storage / GB Month	$.26
Standard Daily Backup / GB Month	$.02
On-Demand Backup/ GB Month	$.02

*Hourly/daily rates available
**OS rates available for Windows, Red Hat, and CENTOS
***Optional

Vendors named within are approved or under contract to provide specified services to DISA or DOD

https://www.disa.mil/-/media/Files/DISA/News/Events/Symposium/milCloud-2-0-May-2018.ashx?la=en&hash=01F92057AA7F936FF7058108C02563936F199A01

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On-Site Managed Services (OMS)

- **Contractor operated cloud solution, located in government data center**

- **Designed to host IIL4/5 Non-classified Internet Protocol (IP) Router Network (NIPRNET) workloads**

  - Eventually IIL-6 through Secure IP Router Network (SIPRNET)

- **Billing in 5 minute increments**

- **Cost considerations:**

  - Bundled VM pricing, with additional charges to customize

  - Additional fees for contract charges, and DoD facility charges

  - Different storage types, and backup options

https://www.smartronix.com/services/Cloud-Computing/Documents/SMX_ServiceSlick_CloudSrvDoD.pdf

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Commercial Private Cloud (COCO-ON)

- **Private cloud physically located on a government installation**

- **Power, cooling, floor space, connectivity, physical access provided by the government to contractor**

- **Equipment & hosting software contractor owned**

- **Service contract, not a lease**

- **IIL-5 certified**

- **Cost considerations:**

  – Monthly only billing

  – Basis of pricing (e.g., complexity-based vs by core/VM/storage/RAM)

Private Cloud

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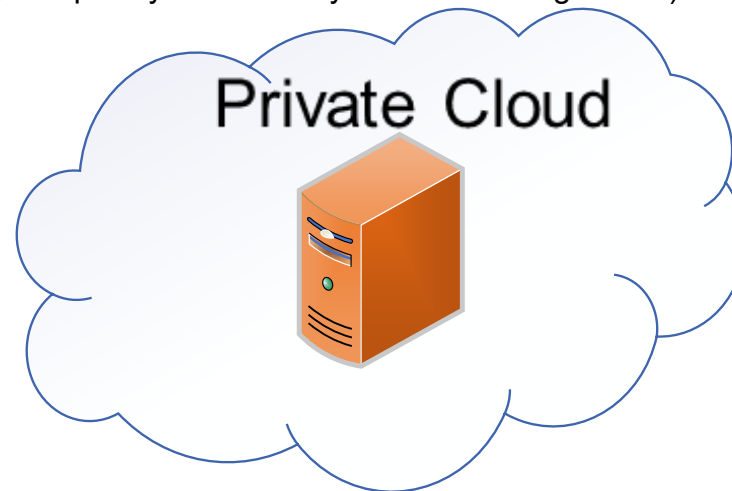
Vignette 3 – IIL-5 Application with Archived Storage

Application to Cost

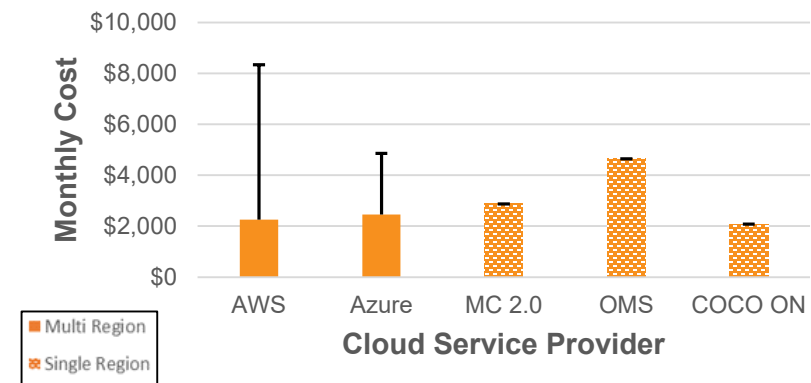| Basic Application Characteristics			
Security Level:	IIL-5		
Region (single/multi):	Multizone		
Hours per Month:	24x7		
Compute	Cores	RAM (GB)	OS
VM 1	2	4	Windows
VM 2	2	4	Windows
VM 3	4	16	Windows
VM 4	4	16	Windows
Storage	Storage Type	Size (GB)	
Primary Storage	High IOPS	5,000	
Backup (Snapshot)	SSD	1000	
Archived Storage	Variable	40,000	
Other (if applicable)			
Data Transfer	Yes	2500 GB/Mo	

Areas of Uncertainty

- **IIL**
  - Service providers may charge different rates for IIL
  - Some providers have an upcharge to go from IIL4 to IIL-5
- **COOP**
  - Restoration and backup options including within the datacenter, within a region and across multiple regions
  - Costs may be doubled to have a fully running backup in another region
- **Archived storage**
  - Some agencies require data to be stored for audit and regulatory requirements for up to 50 years
  - Amazon glacier is pennies to use versus other storage

Questions to Ask

- **Information Impact Level (IIL)**
  - What IIL level is required by the data?
- **Continuity of operation (COOP)**
  - What level of failover is need?
  - How quickly can the application or data be back on line after an event?
- **Archive storage**
  - How often will the data be accessed?
  - How long does the data need to be stored?
  - What options do service providers have with storing this type of data?

Comparison of Cloud Costs with Ranges

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Vignette 4 – IIL-6 Application

Application to Cost

| Basic Application Characteristics			
Security Level:	IIL-6		
Region (single/multi):	Multizone		
Hours per Month:	24x7		
Compute	Cores	RAM (GB)	OS
VM 1	2	4	Windows
VM 2	2	4	Windows
VM 3	4	16	Windows
VM 4	4	16	Windows
Storage	Storage Type	Size (GB)	
Primary Storage	High IOPS	5,000	
Backup (Snapshot)	SSD	1000	
Other (if applicable)			
Data Transfer	Yes	2500 GB/Mo	

Areas of Uncertainty

- **Rates for IIL-6 data**

Questions to Ask

- **Can the service provider host data at IIL-6?**
  - Only AWS is currently certified to host data at IIL 6*

- **What rates apply for IIL-6 data?**
  - AWS rates for their secret cloud region are not publicly available

*https://www.disa.mil/Computing/Cloud-Services/Cloud-Support

Comparison of Cloud Costs with Ranges

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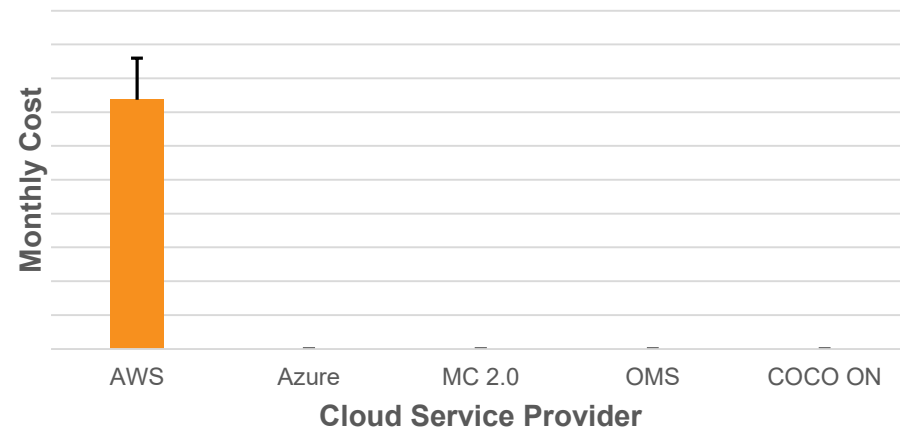
Vignette 5 – Basic Inputs vs Additional Resources

Application to Cost

Compute	Qty	Cores	RAM	OS
VM 1	3	1	1	Linux
VM 2	3	1	2	Linux
VM 3	3	2	4	Linux
DB 1	1	1	1	MySQL
DB 2	1	1	1	MYSQL
DB 3	1	2	4	MYSQL
DB 4	1	2	8	MYSQL

Storage	Type	Size (GB)
Primary Storage	SSD	144
Database Storage	SSD	555
Backup	SSD	54.5

Security Level	IL 2
Region (Single/Multi)	Multizone
Operations	24x7
Other (If Applicable)	
Data Transfer	Yes
Load Balancers	Yes
Elastic Cache	Yes

Areas of Uncertainty

- **Applications can require additional resources when low latency and high performance are required**
  - Not all solutions are equal or available
- **Load Balancers**
  - Commercial service providers offer comparable services at similar price points
  - Unclear if available with milCloud 2.0 or OMS
- **Cached Memory**
  - Commercial service providers offer the service but prices differ substantially, and Google only offers service through third party service (no public prices)
  - Unclear if available with milCloud 2.0 or OMS
- **Multizone and High Availability**
  - Commercial service providers offer options for this service but can drastically increase costs
  - Unclear if available with milCloud 2.0 or OMS

Questions to Ask

- **Load balancers**
  - Does the application require load balancers to spread demand across multiple VMs? If so, determine the quantity based on how each service provider charges for load balancers
  - Does each service provider offer similar capabilities at the proper security level? If not, how is this gap overcome to make an equitable comparison?
- **Cache memory**
  - Does the application require cached storage for low latency performance? If so, determine the quantity based on how each service provider charges for cached memory
  - Does each service provider offer similar capabilities at the proper security level? If not, how is this gap overcome to make an equitable comparison?
- **Multi-regional zones versus single zone Availability**
  - Does the application require availability across multiple regions to allow for failover and COOP?
  - Each service provider may provide this capability with different solution sets. How does each service provider offer that capability?

Comparison of Cloud Costs with Ranges
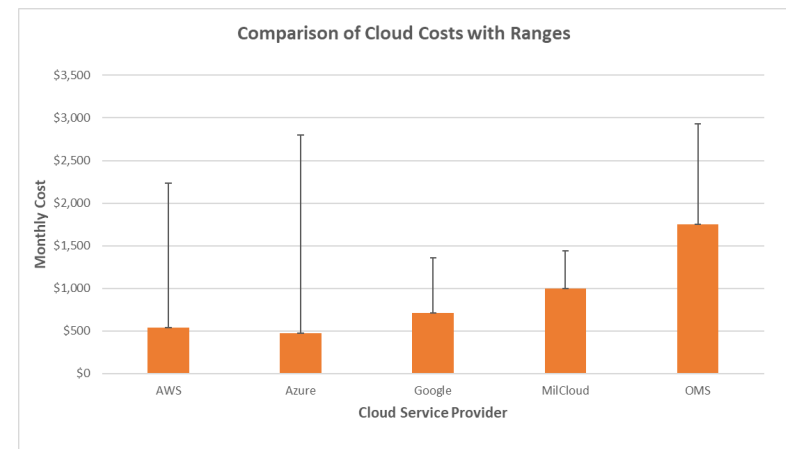
* Google, milCloud and OMS price estimates are incomplete because they do not provide/publish rates for some services required

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Key References

- "*MilCloud®2.0 - Connecting DoD networks to on-site commercial cloud environments*", DISA, June 2018

- "*Comparing Cloud Instant Pricing – AWS vs Azure vs Google vs IBM*", K. Weins, Rightscale, November 2017

- "*Cloud SLA Considerations for the Government Consumer* ", K. Buck/ D. Hanf/ D. Harper, July 2015 (quoted in GAO Reports);

- "*Apples and Oranges: An experience in using cloud Cost Calculators and Rate Cards*", K. Buck/ D Harper/ E. Krebs, June 2016 presented to Int'l Cost Estimating & Analysis Workshop

- "*Cloud Cost Comparison (Case Study)*", B. Girgis/ C. Liou, March 2016,

- "*DoD Cloud Computing Security Requirements Guide (SRG)*", Section 3, 2015.

- "*Introduction to Application Migration to Cloud*", Cloud Computing Learning Path, H. Small/ K. Warren, June 2015.

- "Cloud Vendor Benchmark 2015 Report", http://connect.cloudspectator.com/iaas-price-comparison-2015

- "*Enterprise Cloudonomics – The Economics of Cloud Computing*", J. Jacobs, June 2013

- "Cloud Cost and Business Case Considerations", J. Manring/ R. Agrawal, 2010

- "Army Cloud Migration FAQ Guide 2016"

- "*Cloud Computing Economics – Business Case Template for Cloud Migration*", C. Lehan, 30 September 2015

- "Leveraging the Cloud for Public Sector", S. Anand, 8 Nov 2012

- "*The Truth about Cloud Economics*", Harvard Business Review, D. Reeves/ D. Plummer, April 2012

- "Cost Model for Transition to the Cloud", M. Mclaughlin, 2010

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