AS/400 Disk Arm Requirements Based on Processor Model Performance

Larry Whitley and Jason Clegg
AS/400 System Architecture and Performance
IBM Rochester Lab
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As higher capacity disk (DASD) devices (8GB and 17GB) for the AS/400™e-series become available, *fewer arms* are needed to satisfy the *capacity* requirements. This *can lead to configuring too few disk arms (actuators) to meet the workload* placed on them. **A lack of disk arms can bottleneck the processor's performance.** To avoid such a bottleneck, a *minimum number of disk devices is needed for optimum performance* on each AS/400 processor level. This number is independent of the quantity of drives needed to meet the desired storage capacity.

The worksheets in this paper are used to determine the minimum number of disk arms (DASD) needed for acceptable performance on AS/400 system and server models running multi-user environments. This document is organized as follows:

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Note: The information in the accompanying worksheets and tables is based on studies done by the Rochester Lab for specific sets of transactions and assumptions. The benchmarks used to produce the tables may not accurately reflect your specific environment. Unique customer applications may generate more or less disk activity than the applications used to produce the tables. *The AS/400 capacity planning tools provide the most accurate configuration projections*. They consider not only the processor and disk speeds, but also application requirements, memory capacity, existing drive utilization, etc.

The BEST/1 capacity planning tool, in conjunction with actual customer measurements on an existing system/application, usually provides more accurate information than these worksheets and tables -- since it can rely on the customer's actual workload.

The Workload Estimator for AS/400 assists IBM and Approved IBM Business Partners in projecting an AS/400 model that meets capacity requirements within CPU % utilization objectives. The Workload Estimator for AS/400 is available online at http://as400service.ibm.com/estimator**. BEST/1 continues to be available and recommended for final configurations.**

Also, the information in the worksheets is intended to be used as a **GUIDELINE,** and ***NOT AS UNALTERABLE RULES***. Without data available for particular application scenarios, it is impossible to give definitive, specific rules on numbers of disk arms required in all customer cases. The information here is a best attempt possible as an overall general recommendation that should

apply in many customer situations. It is important to realize that the specifics of individual application scenarios can cause variation in the appropriate number of disks required for each case. Additional information about each specific customer's system coupled with experience and judgment can alter the correct recommendation in individual cases from the general guidelines listed in the table.

Understanding the Worksheets

This edition of the **AS/400 Disk Arms Requirements** document uses worksheets which can be used to calculate the arm requirements. This edition includes the new models 8xx, 2xx, SB2, and SB3. In addition, the worksheets allow the arm requirements to be calculated for systems using the new features #2763 PCI RAID Disk Unit Controller, #4748 PCI RAID Disk Unit Controller, #9767 Disk Unit Controller, and the model #4317 10,000 RPM 8GB Disk and #4318 10,000 RPM 17 GB Disk.

The worksheets use a simple step-by-step approach to calculating the number of disk arms required. All of the data needed to perform the calculations is contained in tables associated with the specific AS/400 models, and in a separate table which provides adjustment factors for the various combinations of IOPs, DASD devices, and protection methods. The data in these tables is based upon the following set of assumptions:

- "Typical" Commercial OLTP or Client/Server transactions are executed.
- The processor generates physical disk accesses as rapidly as the applications and the speed of the processor permit.
- A limitation of **70% processor utilization** is imposed to match the published recommendations for good interactive performance.
- It is assumed that enough memory is installed to meet the recommended paging rates.

Providing at least the number of disk arms calculated using the worksheets ensures that DASD utilization will not exceed the recommended guidelines. Be cautious, however, when configuring server models. The table values selected or used in calculations, need to accurately reflect the manner in which the server is used.

To use the worksheets, one must know or make assumptions about information that includes:

- The Amount of DASD capacity required (including any additional capacity needed for Mirroring/RAID 5 protection, etc.)
- The DASD device type (the tables assume all devices are the same type and capacity)
- The IOP/IOA type
- The System model type, processor feature number, and where applicable, the interactive feature. (The faster the processor, the more likely it will need to "wait" on the disk, therefore the more arms it needs to "keep busy")
- The **estimated CPU utilization** during peak periods of operation. This can be used to prorate the number of arms calculated from the worksheets relative to the 70% utilization assumed. This may be especially appropriate for new systems. For example, on a new processor upgrade, where the CPU is not expected to exceed 35% for the first few months of operation, only half the arms calculated would be required. As CPU usage rises above this amount over time, more arms would be needed. Eventually, at full system capacity, a requirement for the full number shown in the table would be expected. See additional discussion on this point later in the text.
- For Server models, the "type" of workload. "Traditional" Server activities, such as PC file/print serving, e-Mail or Notes/Domino serving, and static-page Internet serving require fewer disk accesses and are primarily sequential. In contrast, OLTP (On-Line Transaction Processing), where "green screen" types of applications have been rewritten to take advantage of client-server features, perform a lot of random disk accesses for each transaction.

*The example below illustrates most of these considerations and shows how **selecting the number of disk drives based solely on their capacity** (and the lowest price for the desired capacity) **could result in inadequate performance.***

Desired system disk capacity: 80 GB (usable capacity), plus RAID-5 parity capacity
CPU model: 820-2396, Interactive feature 1522
Expected CPU utilization: 70%
Expected Server workload: Traditional Client/Server, Light disk usage
Proposed DASD device: # 4318 (17 GB, 10,000 RPM)
IOP type: # 2763 / PCI RAID Disk Unit Controller, RAID-5 Mode

Selection of disk drive feature # 4318 (17 GB, 10000 RPM) might be the first choice, as it meets system capacity needs and requires the minimum number of disks and supporting features, which in turn produces the lowest price. Based only on capacity, 5 disk arms would be sufficient for usable data plus parity in a single RAID-5 array. To determine whether 5 arms are also sufficient for performance, it is necessary to use the worksheet for Model 820, found on page 16. The worksheet is duplicated below, with the values filled in for this example.

Example for 820-2396, interactive feature 1522, with #4318 DASD and #2763 IOA

Worksheet for Model 820 Minimum DASD Arms required for performance	
1. In Table 6, find the processor feature for the desired model. Enter the corresponding processor CPW on line 1.	1) 950
2. In Table 6, find the Interactive Feature for the desired model. Enter the corresponding interactive CPW on line 2. If system does not run interactive workloads, see the discussion of Interactive Features on page 12.	2) 70
3. Subtract line 2 from line 1. Enter the result on line 3. This is the CPW available for server workloads.	3) 880 *(950-70)*
4. In Table 7, for the selected processor feature, find the arm factor for interactive workloads. Enter the value on line 4.	4) 15
5. In Table 7, for the selected processor feature, find the arm factor for the appropriate server workload. Enter the value on line 5. See the introductory material for more information on workload concepts.	5) 56
6. Divide line 2 by line 4. Enter the result on line 6. This is the unadjusted number of arms required to support the interactive workload on an IOP.	6) 4.67 *(70/15)*
7. Divide line 3 by line 5. Enter the result on line 7. This is the unadjusted number of arms required to support the server workload on an IOP.	7) 15.71 (880/56)
8. Add lines 6 and 7, and enter the result on line 8. This is the total unadjusted number of arms.	8) 20.38 *(15.71+4.67)*
9. In Table 1 on page 13, find the hardware adjustment factor corresponding to the IOP, DASD device, and protection method to be used. Enter the number on line 9.	9) 1.19
10. Divide line 8 by line 9 and round the result up to the nearest whole number. Enter the result on line 10. This is the minimum number of DASD arms required for the selected system, hardware configuration, and workload.	10) 18 *(20.38/1.19)*

In the worksheet, two types of values are used from the Model 820 tables. On lines 1 and 2, the CPW values are entered for the selected processor and interactive features. On lines 4 and 5, arm factors are entered for the interactive and server workloads. The arm factors represent, for a #2763 IOA and #4318 disk, the CPW rating for which a single disk arm can handle the disk operations generated by the selected workload. The arm factors are affected by the characteristics of the individual AS/400 models. In the worksheet, an adjustment factor from the IOA/IOP/DASD

Adjustment table on page 13 is used to adjust the number of disk arms for the selected hardware and protection method.

From the worksheet, we find that 18 #4318 disk arms are required to satisfy the minimum performance requirement with a #2763. **Therefore,** 5 Arms would provide sufficient capacity for usable data plus parity in a single RAID 5 Array, **but** do **NOT** satisfy the minimum performance requirement of 18 arms.

By using feature # 4318 (17 GB, 10,000 RPM), 18 arms provide sufficient capacity (usable data plus parity in 2 separate RAID-5 Arrays), *and* provide acceptable performance. Alternatively, we could replace the IOA feature #2763 with IOA feature #4748, and use device feature #4317 (8.58 GB, 10,000 RPM). This would lead to the calculations shown in the worksheet below.

Example for 820-2396, interactive feature 1522 with #4317 DASD and #4748 IOA

Worksheet for Model 820 Minimum DASD Arms required for performance	
1. In Table 6, find the processor feature for the desired model. Enter the corresponding processor CPW on line 1.	1) 950
2. In Table 6, find the Interactive Feature for the desired model. Enter the corresponding interactive CPW on line 2. If system does not run interactive workloads, see the discussion of Interactive Features on page 12.	2) 70
3. Subtract line 2 from line 1. Enter the result on line 3. This is the CPW available for server workloads.	3) 880 *(950-70)*
4. In Table 7, for the selected processor feature, find the arm factor for interactive workloads. Enter the value on line 4.	4) 15
5. In Table 7, for the selected processor feature, find the arm factor for the appropriate server workload. Enter the value on line 5. See the introductory material for more information on workload concepts.	5) 56
6. Divide line 2 by line 4. Enter the result on line 6. This is the unadjusted number of arms required to support the interactive workload on an IOP.	6) 4.67 *(70/15)*
7. Divide line 3 by line 5. Enter the result on line 7. This is the unadjusted number of arms required to support the server workload on an IOP.	7) 15.71 (880/56)
8. Add lines 6 and 7, and enter the result on line 8. This is the total unadjusted number of arms.	8) 20.38 *(15.71+4.67)*
9. In Table 1 on page 13, find the hardware adjustment factor corresponding to the IOP, DASD device, and protection method to be used. Enter the number on line 9.	9) 1.56
10. Divide line 8 by line 9 and round the result up to the nearest whole number. Enter the result on line 10. This is the minimum number of DASD arms required for the selected system, hardware configuration, and workload.	10) 14 *(20.38/1.56)*

Using IOA feature #4748, and device feature #4317 (8.58 GB, 10, 000RPM), 14 disk arms provide sufficient capacity (usable data plus parity in 2 separate RAID-5 Arrays), *and* provide acceptable performance.

From this we can conclude that using either #2763 IOAs with 18 #4318 disk devices, or #4748 IOAs with 14 #4317 disk devices will satisfy both the capacity and performance requirements of the system. Either of the options can be selected, and the final choice may be made based on other considerations, such as the price of the entire configuration.

Workload Discussion -- System and Server Models

Different assumptions are made about the types of workloads and the resulting disk activity occurring on System Models and Server Models.

System Models
For System Models, the tables reflect values that are based solely on Interactive **On-Line Transaction Processing (OLTP) workloads.** These types of applications are characterized by relatively heavy disk utilization per unit of CPU. A large percentage of the disk activity is random, record-oriented retrieval and update processing.

For the larger system models, data content and its usage affects the number of arms required. The percentage of archival, rarely accessed data is generally higher on larger models and systems with larger disk capacities. Therefore, as total system DASD capacity increases, the number of disk accesses/second/GB starts to decrease, thus lowering the number of actuators needed for performance in accessing that data.

Server Models
Server models are more complex and will **require the examination of multiple values within the table** to properly determine the appropriate number of disk drives. These values are termed, "Light, Mixed, and Heavy". The reasons for multiple values are discussed below.

The **Server Models provide *two* levels of performance:** One for "traditional interactive" applications (typically "green screen" functions running in subsystem QINTER); Another for "server" performance (usually referred to as "batch". More properly, this is the performance seen by jobs submitted to the system that achieve the full performance capability of the CPU since they are implemented as batch functions.) This is one reason that **it is difficult to properly size disk activity on Server models via a *single* value.**

Another reason a single value cannot be used for these models, is because "server" functions can have different types of characteristics.

- Some functions place a relatively small, predominantly sequential workload on the disks. These types of functions include: PC file/print serving; Internet serving of "Static" pages (especially those with high graphical content); Lotus Notes/Domino serving; and any activity that performs relatively few random disk accesses. Some of these types of activities heavily exercise the CPU, others do not.

- Some functions perform lots of random disk activity, while using relatively little CPU power. These programs typically perform On-Line Transaction Processing (OLTP).

  When running OLTP applications on the server models, some of the programs will use "Green Screen" approaches. Running in the "interactive" mode, they have a relatively low amount of CPU performance available to them (lower CPW number), but still perform large numbers of random disk accesses. The amount of disk activity generated in this mode is usually limited by the available CPU resource.

  There are also **OLTP programs** that have been **written to take advantage of client-server features.** They perform a lot of random disk accesses for each transaction. Because they are

running as batch functions, the full processing power of the server models (higher CPW number) is available to them. Applications such as these can **generate the same disk workload requirements as those generated by the System models with similar CPW performance values.** Many of the newer applications -- those applications capable of running on the server models -- from some of the largest "traditional" Application Software Vendors can generate these heavier disk workloads on the system.

Query programs, especially those using an access path (alternate index to the data), and **data warehousing** programs, especially when performing "drill down" activities, can also generate large numbers of random disk accesses. These programs take advantage of the higher performance of the server models and can therefore generate heavy disk activity.

To address the various requirements the **Server Model tables present arm factors for three different server workloads:** ***Light, Heavy and Mixed.*** They should not be used blindly. It will often be necessary to "weight" two of the values to obtain a result that matches the customer's actual environment.

Light Disk Workload Environments:

A "Light" disk access rate was determined when running ***only*** server applications that are ***compute-intensive*** and generate relatively few, sequential oriented disk accesses. These transactions ran ***in the "batch" or client/server mode***. Applications such as Lotus Notes/Domino; Internet Web serving of "static" pages, images, and graphics; and some SAP R3 environments fit this category (note that production environments of SAP can sometimes be heavier in disk load than what is created by the Industry Benchmark applications for SAP R3. The Industry Benchmark scenario is aligned with the "Light" concept for SAP R3). These applications produce less load on disk arms than "Interactive" types of applications. Even with relatively high CPU power provided in "server/batch" mode processing, the light use of disk by these applications limits the load on the arms. *Note:* File/Print Serving of PC files also generates relatively little disk activity, but since most of this activity uses an Integrated Netfinity Server (INS), there is relatively little AS/400 CPU activity.

(Note: For older special Mixed Mode Server models, the Light Disk value was determined by examining two environments, then selecting the larger, more conservative number. The first value was determined as mentioned above, for compute-intensive server apps. A second disk access rate was determined for running ***only*** traditional ***OLTP/Interactive applications in "Interactive"*** ("green screen") ***mode.*** Since the full power of the CPU is not available on the Interactive side, lower disk accessing rates occurred than assumed for "Heavy" disk load scenarios. But in some cases, this would provide a higher minimum "Light" load value than that of the compute intensive case. The ***larger of the two values*** generated was listed in the tables as the ***"Light Disk Workload"*** value in such a case).

Heavy Disk Workload Environments:

This value evaluates the server models running ***OLTP types of transactions*** that have been ***written to run in the faster, client/server or "batch" mode (larger CPW value).*** These types of transactions can use the entire CPW performance capability of the CPU and can therefore generate a significant disk workload. The types of programs were discussed earlier. They perform extensive random access processing, often via SQL or ODBC for OLTP apps running on the "batch" side.

Because the programs can generate heavy disk activity, and there is a significant amount of processing power available (larger CPW), the "Heavy Disk Workload" values reflect a requirement for a relatively large number of disk arms.

Mixed Disk Workload Environments:

The arm factor value for mixed workloads is based on a 50/50 weighted mix of the number of disk arms required for the "Light" and "Heavy" Disk Workload values. It is used primarily as an example, and is a "compromise" number. It was created by determining the number of disk arms required for a light workload and heavy workload, and then finding the arm factor that would yield a 50/50 weighting of those values.

It is suggested that you ***do not use*** *this value*, but ***instead, weight the number of arms required to support the Server CPW for "Light" and "Heavy" workload values in a manner that is appropriate for your specific workload.*** To see how this would be done, we use as an example a Model 820-2396, Interactive feature 1522, with IOA feature #4748, and device feature #4317 (8.58 GB, 10,000 RPM),. This is the same system used in the previous example. For this system, using the worksheet on page 16, replicated and filled in below, we see that 15.7 arms are need for the server CPW to support a light workload, and 58.7 arms are needed for a heavy workload. These are the values that are calculated on line 7 of the worksheet, assuming the associated workload. For a 50/50 Mixed Server Disk Workload, we can calculate that (50% x 15.7) + (50% x 58.7) = 37.2 ("unadjusted") Arms minimum are required. This value is then used on line 7 of the worksheet to complete the computations. The end result is the total number of arms required to support and OLTP workload on the interactive CPW plus the mixed workload on the server CPW.

Example:Mixed Workload on Model 820-2396/1522, with #4317 DASD and #4748 IOA

Worksheet for Model 820 Minimum DASD Arms required for performance	
1. In Table 6, find the processor feature for the desired model. Enter the corresponding processor CPW on line 1.	1) 950
2. In Table 6, find the Interactive Feature for the desired model. Enter the corresponding interactive CPW on line 2. If system does not run interactive workloads, see the discussion of Interactive Features on page 12.	2) 70
3. Subtract line 2 from line 1. Enter the result on line 3. This is the CPW available for server workloads.	3) 880 *(950-70)*
4. In Table 7, for the selected processor feature, find the arm factor for interactive workloads. Enter the value on line 4.	4) 15
5. In Table 7, for the selected processor feature, find the arm factor for the appropriate server workload. Enter the value on line 5. See the introductory material for more information on workload concepts.	5) 56 (Light) 15 (Heavy)
6. Divide line 2 by line 4. Enter the result on line 6. This is the unadjusted number of arms required to support the interactive workload on an IOP.	6) 4.7 *(70/15)*
7. Divide line 3 by line 5. Enter the result on line 7. This is the unadjusted number of arms required to support the server workload on an IOP.	7) 15.7 (Light) 58.7 (Heavy) 37.2 (50%)
8. Add lines 6 and 7, and enter the result on line 8. This is the total unadjusted number of arms.	8) 41.9
9. In Table 1 on page 13, find the hardware adjustment factor corresponding to the IOP, DASD device, and protection method to be used. Enter the number on line 9.	9) 1.56
10. Divide line 8 by line 9 and round the result up to the nearest whole number. Enter the result on line 10. This is the minimum number of DASD arms required for the selected system, hardware configuration, and workload.	10) 27

You should weight the two extreme values for ***"Heavy"*** and ***"Light"*** whenever possible by the percentage appropriate to your specific combination of "Light" and "Heavy" Disk workload activity on the system. If you have no idea of the workload balance, the 50% values shown in the tables may be used as a compromise. Recognize however, that depending on the situation, additional disks may need to be added once the workload balance has been determined.

IMPORTANT: ***Do NOT*** use the Mixed Disk Workload values if the server model does Heavy Disk Workload activity during certain periods of time, and Light Disk activity at other times. In this situation, you ***must size for the "worst" case***, and use the Heavy Disk Workload value. The ***Mixed Disk Workload*** value is appropriate ***only*** when the CPU is used ***concurrently*** for both ***"Heavy" and "Light" workloads***.

When sizing for SAP R3, consider that many customers have experienced heavier disk traffic in production vs. that generated by the Industry Benchmark. Thus, actual production SAP environments can span the range of "Light" to "Mixed", depending on each unique customer installation (for second tier). When sizing for SAP in a 3 tier environment, the server workload for the third tier server SAP database is “Heavy”.

Additional Considerations When Using the Tables

Load Source Drive

For proper Disk protection on systems prior to the 6x0 and Sx0 models, the first drive on the system (usually called the "**load source drive**") had to be mirrored, and used a much slower controller than the RAID-capable controllers. The 6x0/Sx0/170/2xx/8xx/SB2/SB3 models allow use of a faster controller that also allows this drive to be used in a RAID-5 array. The tables account for the potential speed difference of the "load source drive" (and it's mirror, where indicated). They *assume all other arms* on a system *have the same speed and capacity.*

Mixing Disk Features

The tables do not attempt to address performance for **mixtures of disk feature capacities** or types. To project performance capabilities on mixed disk-capacity installations, refer to the discussion in Chapter 14 (DASD Performance) of the AS/400 Performance Capabilities Reference (available from the AS/400 online library at http://publib.boulder.ibm.com/pubs/html/as400/online/chgfrm.htm). The chapter contains charts showing "Operations per Second per Gigabyte" (Ops/sec/GB) for various types of drives and controllers. This data can be used to guide decisions on each arm's capacity and mixtures of arms in a particular installation.

Mirrored Environments

In a ***mirrored environment***, *writes* must occur *on both disk drives*. This increases the number of writes that are generated. Therefore, in a mirrored environment, the number of arms required must be increased by the percentage of DASD accesses (for an unmirrored system) that are disk writes. For example, assume a system with a read-to-write ratio of 3-to-1. This means the system does 3 reads for every write (which totals 4 disk accesses). In a mirrored environment, an extra disk access is required for every "write" -- 5 accesses occur (3 reads plus *2 writes)*. This is 25% more activity than the tables show for the "unprotected" environment.

The IOA/IOP/DASD Adjustment Table values for mirroring are based on the assumption that the read-to-write ratio is 2-to-1. This value gives a 33% increase in the amount of disk traffic, and therefore yields a 33% increase in the number of disk arms required.

If possible, when calculating the appropriate number of arms for a system that will employ mirroring, you should adjust the IOA/IOP/DASD adjustment value from Table 1 based on the read-to-write ratio for the system. The read and write information for the system is shown in the Performance Reports. The correct IOA/IOP/DASD adjustment value can be determined by multiplying the value for unprotected systems by the anticipated read percentage. For example, in a system that uses #6533 IOPs and #6717 disk devices, the IOA/IOP/DASD adjustment value from Table 1 for an unprotected system is 1.59. If the system has a read percentage of 55%, then the correct adjustment value to use when calculating the number of disk arms required, when using mirroring with this system and IOA/IOP/DASD combination, is 1.59 * 0.55 , which is 0.87.

If the read-to-write ratio information is not available, the value from Table 1 for mirroring may be used. Recognize however, that depending on the situation, additional disks may need to be added once the actual read-to-write ratio has been determined.
Note: Some measurements of server applications such as Lotus Notes/Domino and SAP-R3 use read-to-write ratios as high as 40%-50% (in part due to very efficient internal caching of the reads).

CPU Utilization Considerations

The simple assumption for the table is that the CPU is running near its recommended limit for interactive activity -- 70% during peak periods. It is recognized that in many cases, systems are not pushed to this limit at new installations in particular. If it is known that full CPU capacity is not expected to be used while the DASD configuration under consideration is installed, then the table value for arms required may be prorated. For example, on a processor model upgrade, where additional work is not expected to be added to the system for some time, it might be projected that the CPU for interactive work is not to exceed 35% during peak periods. In this case, the number of arms required would be half of the table value.

***CAUTION*:** Ensure that the highest planned system usage is considered over time. As additional work is added to the system, **more disk arms** are required. When the total work exceeds the peak usage amount assumed in this planning exercise, DASD hardware upgrades will likely be required if a prorated number of disks is selected vs. the values shown in the table. The listed information assumes that the total number of arms needed as the system approaches its full interactive capacity matches the values shown.

Journaling

The numbers of disk arms listed in the table do **NOT** include drives for journal receiver arms in separate, dedicated ASPs. Arms configured specially for journal activity are in addition to those listed in the tables.

The performance of the journal arms is greatly reduced by non-journaling disk traffic directed to the same disk arms. This is due to the sequential nature of the journaling operations. Therefore, for best performance, journal receiver arms should be placed in a separate, dedicated ASP. The performance of the journal receiver arms can be improved further if this ASP is mirrored, rather than protected using RAID-5. The parity operations generated by RAID-5 also interfere with the sequential nature of journaling traffic.

Interactive Features

The calculations in the worksheets assume that the full CPW available with the selected interactive feature will be used for interactive OLTP workloads. In some cases, such as systems with the smallest available interactive feature, this assumption may not apply. If it is known that the system will run ***only*** client-server applications that are ***compute-intensive*** and generate relatively few, sequential disk accesses, then the computation of the disk arm requirements for the interactive CPW can be omitted. In this case, enter 0 (zero) for the interactive CPW on line 2 of the worksheets for the server models.

IOA/IOP/DASD Adjustments to Arm Requirements

The number of disk arms required to support a given workload on any AS/400 model will be affected by the combination of IOP and DASD features selected. The number of disk arms required will also be affected by the use of RAID-5 or mirroring capabilities. The table on this page gives adjustment factors for each combination of IOP, DASD, and protection method. This adjustment factor is used to adjust the AS/400 model-specific disk-arm recommendations on the following pages for differences in the selected hardware configuration.

Table 1 - IOA/IOP/DASD Adjustment Factors

Controller:	MFIOP, 9728, 9767, or 6530		Internal: 65x2/3 /2726/2740,2741, 2763, 975x, 9337 4xx/59x: 6501		Internal: 2748, 4748	
Drive Model / Capacity or 9337 Model:	6605 - 1GB xx06 - 2GB xx07 - 4GB xx13 - 8GB xx14 -17GB xx24 -17GB	xx17 - 8GB xx18 - 17 GB	6605 - 1GB xx06 - 2GB xx07 - 4GB xx13 - 8GB xx14 - 17GB xx24 -17GB 9337- 4xx 9337 - 5xx	xx17 - 8GB xx18 - 17 GB	6605 - 1GB xx06 - 2GB xx07 - 4GB xx13 - 8GB xx14 - 17GB xx24 - 17GB	xx17 - 8GB xx18 - 17 GB
	Hardware Adjustment Factor					
No Protection	1.00	1.15	1.38	1.59	1.59	2.07
RAID-5	N/A	N/A	1.04	1.19	1.19	1.56
Mirroring	0.75	0.86	1.04	1.19	1.19	1.56

Notes:

1. The adjustment factors for mirroring assume a read-to-write ratio of 2-to-1, and therefore represent a 33% decrease from the adjustments for no protection. If the read-to-write ratio for the system is different, the correct adjustment factor should be selected by ***decreasing*** the adjustment factor from the "No Protection" row of the table by the appropriate amount. See the introductory text for details
2. For detailed information on the performance characteristics of these DASD arms, refer to Chapter 14 (DASD Performance) in the **AS/400 Performance Capabilities Reference** available online at http://publib.boulder.ibm.com/pubs/html/as400/online/chgfrm.htm

Minimum DASD Arms Required for Performance
AS/400 Model **840**

In order to determine the number of disk arms needed for optimum performance for an AS/400 Model 840, follow the instructions in the worksheet below. The results are for a specific benchmark @ 70% CPU Utilization. Your application may produce a different system load.
Note: Mixed Disk Load values are an example of 50% Light Load plus 50% Heavy Load. Use the actual percentages for your case when determining minimum arms for the Mixed environment. (See introductory text for details). Heavy Disk Load scenarios apply to the percentage of time the system runs OLTP types of applications that have been written to run in the faster, client/server "batch" mode. Light Disk Load scenarios apply to the percentage of time the system runs newer server applications that are more compute-intense, and run in client/server "batch" mode. The introductory text gives more details on these concepts.

Worksheet for Model 840 Minimum DASD Arms required for performance		Example: Model 840-2420/1540 , Light server workload, 4748 IOA, 4317 DASD, RAID-5	Example: Model 840-2420/1540 , Heavy server workload, 4748 IOA, 4317 DASD, RAID-5
1. In Table 2, find the processor feature for the desired model. Enter the corresponding processor CPW on line 1.	1)	1) 16500	1) 16500
2. In Table 2, find the Interactive Feature for the desired model. Enter the corresponding interactive CPW on line 2. If system does not run interactive workloads, see the discussion of Interactive Features on page 12.	2)	2) 120	2) 120
3. Subtract line 2 from line 1. Enter the result on line 3. This is the CPW available for server workloads.	3)	3) 16380	3) 16380
4. In Table 3, for the selected processor feature, find the arm factor for interactive workloads. Enter the value on line 4.	4)	4) 22	4) 22
5. In Table 3, for the selected processor feature, find the arm factor for the appropriate server workload. Enter the value on line 5. See the introductory material for more information on workload concepts.	5)	5) 111	5) 22
6. Divide line 2 by line 4. Enter the result on line 6. This is the unadjusted number of arms required to support the interactive workload on an IOP.	6)	6) 5.5	6) 5.5
7. Divide line 3 by line 5. Enter the result on line 7. This is the unadjusted number of arms required to support the server workload on an IOP.	7)	7) 147.6	7) 744.7
8. Add lines 6 and 7, and enter the result on line 8. This is the total unadjusted number of arms.	8)	8) 153.1	8) 750
9. In Table 1 on page 13, find the hardware adjustment factor corresponding to the IOP, DASD device, and protection method to be used. Enter the number on line 9.	9)	9) 1.56	9) 1.56
10. Divide line 8 by line 9 and round the result up to the nearest whole number. Enter the result on line 10. This is the minimum number of DASD arms required for the selected system, hardware configuration, and workload.	10)	10) 99	10) 481

Table 2 - Model 840 CPW

Processor Feature	**Processor CPW**	**Interactive Features**							
		1547	**1546**	**1545**	**1544**	**1543**	**1542**	**1541**	**1540**
2420	16500	16500	10000	4550	2000	1050	560	240	120
2418	10000	N/A	10000	4550	2000	1050	560	240	120

Table 3 - Model 840 Arm Factors

Processor Feature	**Workload**			
	Interactive	**Server - Light**	**Server - Mixed**	**Server - Heavy**
2420	22	111	37	22
2418	21	107	36	21

Minimum DASD Arms Required for Performance
AS/400 Model **830**

In order to determine the number of disk arms needed for optimum performance for an AS/400 Model 830, follow the instructions in the worksheet below. The results are for a specific benchmark @ 70% CPU Utilization. Your application may produce a different system load.
Note: Mixed Disk Load values are an example of 50% Light Load plus 50% Heavy Load. Use the actual percentages for your case when determining minimum arms for the Mixed environment. (See introductory text for details). Heavy Disk Load scenarios apply to the percentage of time the system runs OLTP types of applications that have been written to run in the faster, client/server "batch" mode. Light Disk Load scenarios apply to the percentage of time the system runs newer server applications that are more compute-intense, and run in client/server "batch" mode. The introductory text gives more details on these concepts.

Worksheet for Model 830 Minimum DASD Arms required for performance		Example: Model 830-2402/1533 , Light server workload, 4748 IOA, 4317 DASD, RAID-5	Example: Model 830-2403/1533 , Heavy server workload, 4748 IOA, 4317 DASD, RAID-5
1. In Table 4, find the processor feature for the desired model. Enter the corresponding processor CPW on line 1.	1)	1) 4200	1) 7350
2. In Table 4, find the Interactive Feature for the desired model. Enter the corresponding interactive CPW on line 2. If system does not run interactive workloads, see the discussion of Interactive Features on page 12.	2)	2) 240	2) 240
3. Subtract line 2 from line 1. Enter the result on line 3. This is the CPW available for server workloads.	3)	3) 3960	3) 7110
4. In Table 5, for the selected processor feature, find the arm factor for interactive workloads. Enter the value on line 4.	4)	4) 19	4) 17
5. In Table 5, for the selected processor feature, find the arm factor for the appropriate server workload. Enter the value on line 5. See the introductory material for more information on workload concepts.	5)	5) 93	5) 17
6. Divide line 2 by line 4. Enter the result on line 6. This is the unadjusted number of arms required to support the interactive workload on an IOP.	6)	6) 12.6	6) 14.1
7. Divide line 3 by line 5. Enter the result on line 7. This is the unadjusted number of arms required to support the server workload on an IOP.	7)	7) 42.6	7) 418.2
8. Add lines 6 and 7, and enter the result on line 8. This is the total unadjusted number of arms.	8)	8) 55.2	8) 432.3
9. In Table 1 on page 13, find the hardware adjustment factor corresponding to the IOP, DASD device, and protection method to be used. Enter the number on line 9.	9)	9) 1.56	9) 1.56
10. Divide line 8 by line 9 and round the result up to the nearest whole number. Enter the result on line 10. This is the minimum number of DASD arms required for the selected system, hardware configuration, and workload.	10)	10) 36	10) 278

Table 4 - Model 830 CPW

Processor Feature	Processor CPW	Interactive Features						
		1537	1536	1535	1534	1533	1532	1531
2403	7350	4550	2000	1050	560	240	120	70
2402	4200	N/A	2000	1050	560	240	120	70
2400	1850	N/A	N/A	1050	560	240	120	70

Table 5 - Model 830 Arm Factors

Processor Feature	Workload			
	Interactive	Server - Light	Server - Mixed	Server - Heavy
2403	17	88	29	17
2402	19	93	31	19
2400	17	62	26	17

Minimum DASD Arms Required for Performance
AS/400 Model **820**

In order to determine the number of disk arms needed for optimum performance for an AS/400 Model 820, follow the instructions in the worksheet below. The results are for a specific benchmark @ 70% CPU Utilization. Your application may produce a different system load.
Note: Mixed Disk Load values are an example of 50% Light Load plus 50% Heavy Load. Use the actual percentages for your case when determining minimum arms for the Mixed environment. (See introductory text for details). Heavy Disk Load scenarios apply to the percentage of time the system runs OLTP types of applications that have been written to run in the faster, client/server "batch" mode. Light Disk Load scenarios apply to the percentage of time the system runs newer server applications that are more compute-intense, and run in client/server "batch" mode. The introductory text gives more details on these concepts.

Worksheet for Model 820 Minimum DASD Arms required for performance		Example: Model 820-2396/1522 , Light server workload, 4748 IOA, 4317 DASD, RAID-5	Example: Model 820-2398/1522 , Heavy server workload, 4748 IOA, 4317 DASD, RAID-5
1. In Table 6, find the processor feature for the desired model. Enter the corresponding processor CPW on line 1.	1)	1) 950	1) 3200
2. In Table 6, find the Interactive Feature for the desired model. Enter the corresponding interactive CPW on line 2. If system does not run interactive workloads, see the discussion of Interactive Features on page 12.	2)	2) 70	2) 70
3. Subtract line 2 from line 1. Enter the result on line 3. This is the CPW available for server workloads.	3)	3) 880	3) 3130
4. In Table 7, for the selected processor feature, find the arm factor for interactive workloads. Enter the value on line 4.	4)	4) 15	4) 15
5. In Table 7, for the selected processor feature, find the arm factor for the appropriate server workload. Enter the value on line 5. See the introductory material for more information on workload concepts.	5)	5) 56	5) 15
6. Divide line 2 by line 4. Enter the result on line 6. This is the unadjusted number of arms required to support the interactive workload on an IOP.	6)	6) 4.7	6) 4.7
7. Divide line 3 by line 5. Enter the result on line 7. This is the unadjusted number of arms required to support the server workload on an IOP.	7)	7) 15.7	7) 208.7
8. Add lines 6 and 7, and enter the result on line 8. This is the total unadjusted number of arms.	8)	8) 20.4	8) 213.4
9. In Table 1 on page 13, find the hardware adjustment factor corresponding to the IOP, DASD device, and protection method to be used. Enter the number on line 9.	9)	9) 1.56	9) 1.56
10. Divide line 8 by line 9 and round the result up to the nearest whole number. Enter the result on line 10. This is the minimum number of DASD arms required for the selected system, hardware configuration, and workload.	10)	10) 14	10) 137

Table 6 - Model 820 CPW

Processor Feature	**Processor CPW**	**Interactive Features**						
		1527	**1526**	**1525**	**1524**	**1523**	**1522**	**1521**
2398	3200	2000	1050	560	240	120	70	35
2397	2000	N/A	1050	560	240	120	70	35
2396	950	N/A	N/A	560	240	120	70	35
2395	370	N/A	N/A	N/A	240	120	70	35

Table 7 - Model 820 Arm Factors

Processor Feature	**Workload**			
	Interactive	**Server - Light**	**Server - Mixed**	**Server - Heavy**
2398	15	73	24	15
2297	16	83	28	16
2396	15	56	23	15
2395	14	46	21	14

Minimum DASD Arms Required for Performance
AS/400 Model **270**

In order to determine the number of disk arms needed for optimum performance for an AS/400 Model 270, follow the instructions in the worksheet below. The results are for a specific benchmark @ 70% CPU Utilization. Your application may produce a different system load.
Note: Mixed Disk Load values are an example of 50% Light Load plus 50% Heavy Load. Use the actual percentages for your case when determining minimum arms for the Mixed environment. (See introductory text for details). Heavy Disk Load scenarios apply to the percentage of time the system runs OLTP types of applications that have been written to run in the faster, client/server "batch" mode. Light Disk Load scenarios apply to the percentage of time the system runs newer server applications that are more compute-intense, and run in client/server "batch" mode. The introductory text gives more details on these concepts.

Worksheet for Model 270 Minimum DASD Arms required for performance		Example: Model 270-2252/1519 , Light server workload, 4748 IOP, 4317 DASD, RAID-5
1. In Table 8, find the processor feature for the desired model. Enter the corresponding processor CPW on line 1.	1)	1) 950
2. In Table 8, find the Interactive Feature for the desired model. Enter the corresponding interactive CPW on line 2. If system does not run interactive workloads, see the discussion of Interactive Features on page 12.	2)	2) 50
3. Subtract line 2 from line 1. Enter the result on line 3. This is the CPW available for server workloads.	3)	3) 900
4. In Table 9, for the selected processor feature, find the arm factor for interactive workloads. Enter the value on line 4.	4)	4) 15
5. In Table 9, for the selected processor feature, find the arm factor for the appropriate server workload. Enter the value on line 5. See the introductory material for more information on workload concepts.	5)	5) 56
6. Divide line 2 by line 4. Enter the result on line 6. This is the unadjusted number of arms required to support the interactive workload on an IOP.	6)	6) 3.3
7. Divide line 3 by line 5. Enter the result on line 7. This is the unadjusted number of arms required to support the server workload on an IOP.	7)	7) 16.1
8. Add lines 6 and 7, and enter the result on line 8. This is the total unadjusted number of arms.	8)	8) 19.4
9. In Table 1 on page 13, find the hardware adjustment factor corresponding to the IOP, DASD device, and protection method to be used. Enter the number on line 9.	9)	9) 1.56
10. Divide line 8 by line 9 and round the result up to the nearest whole number. Enter the result on line 10. This is the minimum number of DASD arms required for the selected system, hardware configuration, and workload.	10)	10) 13

Table 8 - Model 270 CPW

Processor Feature	Processor CPW	Interactive Features				
		1520	1519	1518	1517	1516
2253	2,000	70	N/A	N/A	N/A	0
2252	950	N/A	50	N/A	N/A	0
2250	370	N/A	N/A	30	N/A	0
2248	150	N/A	N/A	N/A	25	N/A

Table 9 - Model 270 Arm Factors

Processor Feature	Workload			
	Interactive	Server - Light	Server - Mixed	Server - Heavy
2253	16	83	28	16
2252	15	56	23	15
2250	14	46	21	14
2248	10	50	16	10

Minimum DASD Arms Required for Performance
AS/400 Model **250**

In order to determine the number of disk arms needed for optimum performance for an AS/400 Model 250, follow the instructions in the worksheet below. The results are for a specific benchmark @ 70% CPU Utilization. Your application may produce a different system load.
Note: Mixed Disk Load values are an example of 50% Light Load plus 50% Heavy Load. Use the actual percentages for your case when determining minimum arms for the Mixed environment. (See introductory text for details).

Worksheet for Model 250 Minimum DASD Arms required for performance		Example: Model 250-2295, light server workload, 9767 IOP, 6817 DASD, Mirroring
1. In Table 10, find the processor feature for the desired model. Enter the corresponding processor CPW on line 1.	1)	1) 50
2. In Table 10, find the Interactive CPW for the desired model. Enter it on line 2. If system does not run interactive workloads, see the discussion of Interactive Features on page 12.	2)	2) 15
3. Subtract line 2 from line 1. Enter the result on line 3. This is the CPW available for server workloads.	3)	3) 35
4. In Table 10, for the desired model, find the arm factor for interactive workloads. Enter the value on line 4.	4)	4) 8
5. In Table 10, for the desired model, find the arm factor for the appropriate server workload. Enter the value on line 5. See the introductory material for more information on workload concepts.	5)	5) 25
6. Divide line 2 by line 4. Enter the result on line 6. This is the unadjusted number of arms required to support the interactive workload on a base MFIOP.	6)	6) 1.88
7. Divide line 3 by line 5. Enter the result on line 7. This is the unadjusted number of arms required to support the server workload on a base MFIOP.	7)	7) 1.4
8. Add lines 6 and 7, and enter the result on line 8. This is the total unadjusted number of arms.	8)	8) 3.28
9. In Table 1 on page 13, find the hardware adjustment factor corresponding to the IOP, DASD device, and protection method to be used. Enter the number on line 9.	9)	9) 0.86
10. Divide line 8 by line 9 and round the result up to the nearest whole number. Enter the result on line 10. This is the minimum number of DASD arms required for the selected system, hardware configuration, and workload.	10)	10) 4

Table 10 - Model 250 CPW and Arm Factors

Processor Feature	**Processor CPW**	**Interactive CPW**	**Arm Factors by Workload**			
			Interactive	**Server - Light**	**Server - Mixed**	**Server - Heavy**
2296	75	20	10	38	16	10
2295	50	15	8	25	12	8

Minimum DASD Arms Required for Performance
AS/400 Dedicated Server for Domino Model **820**

In order to determine the number of disk arms needed for optimum performance for an AS/400 Dedicated Server for Domino Model 820, follow the instructions in the worksheet below. The results are for a specific benchmark @ 70% CPU Utilization. Your application may produce a different system load.

Worksheet for Model 820 Minimum DASD Arms required for performance		Example: Model 820-2427, MCU workload, 4748 IOA, 4317 DASD, RAID-5
1. In Table 11, find the processor feature for the desired model. Enter the corresponding processor "Mail and Calendaring Users" (MCU) on line 1.	1)	1) 9890
2. In Table 12, for the selected processor feature, find the arm factor for Domino workload. Enter the value on line 2.	2)	2) 225
3. Divide line 1 by line 2. Enter the result on line3. This is the unadjusted number of arms required to support the interactive workload on a base IOP.	3)	3) 43.96
4. In Table 1 on page 13, find the hardware adjustment factor corresponding to the IOP, DASD device, and protection method to be used. Enter the number on line 4.	4)	4) 1.56
5. Divide line 3 by line 4 and round the result up to the nearest whole number. Enter the result on line 5. This is the minimum number of DASD arms required for the selected system, hardware configuration, and workload.	5)	5) 29

Table 11 - Model 820 CPW

Processor Feature	**Processor MCU**
2427	9890
2426	5610
2425	2570

Table 12 - Model 820 Arm Factors

Processor Feature	**Workload**
	DOMINO
2427	225
2426	234
2425	151

Minimum DASD Arms Required for Performance
AS/400 Dedicated Server for Domino Model **270**

In order to determine the number of disk arms needed for optimum performance for an AS/400 Dedicated Server for Domino Model 270, follow the instructions in the worksheet below. The results are for a specific benchmark @ 70% CPU Utilization. Your application may produce a different system load.

Worksheet for Model 270 Minimum DASD Arms required for performance		Example: Model 270-2423, MCU workload, 4748 IOA, 4317 DASD, RAID-5
1. In Table 13, find the processor feature for the desired model. Enter the corresponding processor "Mail and Calendaring Users" (MCU) on line 1.	1)	1) 2570
2. In Table 14, for the selected processor feature, find the arm factor for Domino workload. Enter the value on line 2.	2)	2) 151
3. Divide line 1 by line 2. Enter the result on line3. This is the unadjusted number of arms required to support the interactive workload on a base IOP.	3)	3) 17.02
4. In Table 1 on page 13, find the hardware adjustment factor corresponding to the IOP, DASD device, and protection method to be used. Enter the number on line 4.	4)	4) 1.56
5. Divide line 3 by line 4 and round the result up to the nearest whole number. Enter the result on line 5. This is the minimum number of DASD arms required for the selected system, hardware configuration, and workload.	5)	5) 11

Table 13 - Model 270 CPW

Processor Feature	**Processor MCU**
2424	5,050
2423	2,570
2422	1,600

Table 14 - Model 270 Arm Factors

Processor Feature	**Workload**
	DOMINO
2424	210
2423	151
2422	200

Minimum DASD Arms Required for Performance
AS/400 Model **740**

In order to determine the number of disk arms needed for optimum performance for an AS/400 Model 740, follow the instructions in the worksheet below. The results are for a specific benchmark @ 70% CPU Utilization. Your application may produce a different system load.
Note: Mixed Disk Load values are an example of 50% Light Load plus 50% Heavy Load. Use the actual percentages for your case when determining minimum arms for the Mixed environment. (See introductory text for details). Heavy Disk Load scenarios apply to the percentage of time the system runs OLTP types of applications that have been written to run in the faster, client/server "batch" mode. Light Disk Load scenarios apply to the percentage of time the system runs newer server applications that are more compute-intense, and run in client/server "batch" mode. The introductory text gives more details on these concepts.

Worksheet for Model 740 Minimum DASD Arms required for performance		Example: Model 740-2069/1510, Light server workload, 6533 IOP, 6613 DASD, RAID-5
1. In Table 15, find the processor feature for the desired model. Enter the corresponding processor CPW on line 1.	1)	1) 3660
2. In Table 15, find the Interactive Feature for the desired model. Enter the corresponding interactive CPW on line 2. If system does not run interactive workloads, see the discussion of Interactive Features on page 12.	2)	2) 1050
3. Subtract line 2 from line 1. Enter the result on line 3. This is the CPW available for server workloads.	3)	3) 2610
4. In Table 16, for the selected processor feature, find the arm factor for interactive workloads. Enter the value on line 4.	4)	4) 16
5. In Table 16, for the selected processor feature, find the arm factor for the appropriate server workload. Enter the value on line 5. See the introductory material for more information on workload concepts.	5)	5) 81
6. Divide line 2 by line 4. Enter the result on line 6. This is the unadjusted number of arms required to support the interactive workload on a base MFIOP.	6)	6) 65.6
7. Divide line 3 by line 5. Enter the result on line 7. This is the unadjusted number of arms required to support the server workload on a base MFIOP.	7)	7) 32.2
8. Add lines 6 and 7, and enter the result on line 8. This is the total unadjusted number of arms.	8)	8) 97.8
9. In Table 1 on page 13, find the hardware adjustment factor corresponding to the IOP, DASD device, and protection method to be used. Enter the number on line 9.	9)	9) 1.04
10. Divide line 8 by line 9 and round the result up to the nearest whole number. Enter the result on line 10. This is the minimum number of DASD arms required for the selected system, hardware configuration, and workload.	10)	10) 95

Table 15 - Model 740 CPW

Processor Feature	**Processor CPW**	**Interactive Features**				
		1513	**1512**	**1511**	**1510**	**1514**
2070	4550	4550	3660	2000	1050	120
2069	3660	N/A	3660	2000	1050	120

Table 16 - Model 740 Arm Factors

Processor Feature	**Workload**			
	Interactive	**Server - Light**	**Server - Mixed**	**Server - Heavy**
2070	14	71	24	14
2069	16	81	27	16

Minimum DASD Arms Required for Performance
AS/400 Model **730**

In order to determine the number of disk arms needed for optimum performance for an AS/400 Model 730, follow the instructions in the worksheet below. The results are for a specific benchmark @ 70% CPU Utilization. Your application may produce a different system load.
Note: Mixed Disk Load values are an example of 50% Light Load plus 50% Heavy Load. Use the actual percentages for your case when determining minimum arms for the Mixed environment. (See introductory text for details). Heavy Disk Load scenarios apply to the percentage of time the system runs OLTP types of applications that have been written to run in the faster, client/server "batch" mode. Light Disk Load scenarios apply to the percentage of time the system runs newer server applications that are more compute-intense, and run in client/server "batch" mode. The introductory text gives more details on these concepts.

Worksheet for Model 730 Minimum DASD Arms required for performance		Example: Model 730-2067/1509, Heavy server workload, 2748 IOP, 6717 DASD, RAID-5
1. In Table 17, find the processor feature for the desired model. Enter the corresponding processor CPW on line 1.	1)	1) 2000
2. In Table 17, find the Interactive Feature for the desired model. Enter the corresponding interactive CPW on line 2. If system does not run interactive workloads, see the discussion of Interactive Features on page 12.	2)	2) 560
3. Subtract line 2 from line 1. Enter the result on line 3. This is the CPW available for server workloads.	3)	3) 1440
4. In Table 18, for the selected processor feature, find the arm factor for interactive workloads. Enter the value on line 4.	4)	4) 13
5. In Table 18, for the selected processor feature, find the arm factor for the appropriate server workload. Enter the value on line 5. See the introductory material for more information on workload concepts.	5)	5) 13
6. Divide line 2 by line 4. Enter the result on line 6. This is the unadjusted number of arms required to support the interactive workload on a base MFIOP.	6)	6) 43.1
7. Divide line 3 by line 5. Enter the result on line 7. This is the unadjusted number of arms required to support the server workload on a base MFIOP.	7)	7) 110.8
8. Add lines 6 and 7, and enter the result on line 8. This is the total unadjusted number of arms.	8)	8) 153.9
9. In Table 1 on page 13, find the hardware adjustment factor corresponding to the IOP, DASD device, and protection method to be used. Enter the number on line 9.	9)	9) 1.56
10. Divide line 8 by line 9 and round the result up to the nearest whole number. Enter the result on line 10. This is the minimum number of DASD arms required for the selected system, hardware configuration, and workload.	10)	10) 99

Table 17 - Model 730 CPW

Processor Feature	**Processor CPW**	**Interactive Features**					
		1511	**1510**	**1509**	**1508**	**1507**	**1506**
2068	2,890	2,000	1,050	560	240	N/A	70
2067	2,000	2,000	1,050	560	240	N/A	70
2066	1,050	N/A	1,050	560	240	120	70
2065	560	N/A	N/A	560	240	120	70

Table 18 - Model 730 Arm Factors

Processor Feature	**Workload**			
	Interactive	**Server - Light**	**Server - Mixed**	**Server - Heavy**
2068	15	72	24	15
2067	13	65	21	13
2066	13	48	21	13
2065	13	47	21	13

Minimum DASD Arms Required for Performance
AS/400 Model **720**

In order to determine the number of disk arms needed for optimum performance for an AS/400 Model 720, follow the instructions in the worksheet below. The results are for a specific benchmark @ 70% CPU Utilization. Your application may produce a different system load.
Note: Mixed Disk Load values are an example of 50% Light Load plus 50% Heavy Load. Use the actual percentages for your case when determining minimum arms for the Mixed environment. (See introductory text for details). Heavy Disk Load scenarios apply to the percentage of time the system runs OLTP types of applications that have been written to run in the faster, client/server "batch" mode. Light Disk Load scenarios apply to the percentage of time the system runs newer server applications that are more compute-intense, and run in client/server "batch" mode. The introductory text gives more details on these concepts.

Worksheet for Model 720 Minimum DASD Arms required for performance		Example: Model 720-2062/1502, Light server workload, 6533 IOP, 6717 DASD, Mirroring
1. In Table 19, find the processor feature for the desired model. Enter the corresponding processor CPW on line 1.	1)	1) 420
2. In Table 19, find the Interactive Feature for the desired model. Enter the corresponding interactive CPW on line 2. If system does not run interactive workloads, see the discussion of Interactive Features on page 12.	2)	2) 120
3. Subtract line 2 from line 1. Enter the result on line 3. This is the CPW available for server workloads.	3)	3) 300
4. In Table 20, for the selected processor feature, find the arm factor for interactive workloads. Enter the value on line 4.	4)	4) 14
5. In Table 20, for the selected processor feature, find the arm factor for the appropriate server workload. Enter the value on line 5. See the introductory material for more information on workload concepts.	5)	5) 53
6. Divide line 2 by line 4. Enter the result on line 6. This is the unadjusted number of arms required to support the interactive workload on a base MFIOP.	6)	6) 8.6
7. Divide line 3 by line 5. Enter the result on line 7. This is the unadjusted number of arms required to support the server workload on a base MFIOP.	7)	7) 5.7
8. Add lines 6 and 7, and enter the result on line 8. This is the total unadjusted number of arms.	8)	8) 14.3
9. In Table 1 on page 13, find the hardware adjustment factor corresponding to the IOP, DASD device, and protection method to be used. Enter the number on line 9.	9)	9) 1.19
10. Divide line 8 by line 9 and round the result up to the nearest whole number. Enter the result on line 10. This is the minimum number of DASD arms required for the selected system, hardware configuration, and workload.	10)	10) 12

Table 19 - Model 720 CPW

Processor Feature	**Processor CPW**	**Interactive Features**					
		1505	**1504**	**1503**	**1502**	**1501**	**1500**
2064	1600	1050	560	240	120	N/A	35
2063	810	N/A	560	240	120	N/A	35
2062	420	N/A	N/A	240	120	70	35
2061	240	N/A	N/A	N/A	120	70	35

Table 20 - Model 720 Arm Factors

Processor Feature	**Workload**			
	Interactive	**Server - Light**	**Server - Mixed**	**Server - Heavy**
2064	14	53	23	14
2063	14	51	22	14
2062	14	53	21	14
2061	12	48	19	12

Minimum DASD Arms Required for Performance
AS/400 Model **170**

In order to determine the number of disk arms needed for optimum performance for an AS/400 Model 170, follow the instructions in the worksheet below. The results are for a specific benchmark @ 70% CPU Utilization. Your application may produce a different system load.
Note: Mixed Disk Load values are an example of 50% Light Load plus 50% Heavy Load. Use the actual percentages for your case when determining minimum arms for the Mixed environment. (See introductory text for details).

Worksheet for Model 170 Minimum DASD Arms required for performance		Example: Model 170-2386, light server workload, 2740 IOP, 6707 DASD, RAID-5
1. In Table 21, find the processor feature for the desired model. Enter the corresponding processor CPW on line 1.	1)	1) 460
2. In Table 21, find the Interactive CPW for the desired model. Enter it on line 2. If system does not run interactive workloads, see the discussion of Interactive Features on page 12.	2)	2) 70
3. Subtract line 2 from line 1. Enter the result on line 3. This is the CPW available for server workloads.	3)	3) 390
4. In Table 21, for the desired model, find the arm factor for interactive workloads. Enter the value on line 4.	4)	4) 13
5. In Table 21, for the desired model, find the arm factor for the appropriate server workload. Enter the value on line 5. See the introductory material for more information on workload concepts.	5)	5) 46
6. Divide line 2 by line 4. Enter the result on line 6. This is the unadjusted number of arms required to support the interactive workload on a base MFIOP.	6)	6) 5.4
7. Divide line 3 by line 5. Enter the result on line 7. This is the unadjusted number of arms required to support the server workload on a base MFIOP.	7)	7) 8.5
8. Add lines 6 and 7, and enter the result on line 8. This is the total unadjusted number of arms.	8)	8) 13.9
9. In Table 1 on page 13, find the hardware adjustment factor corresponding to the IOP, DASD device, and protection method to be used. Enter the number on line 9.	9)	9) 1.04
10. Divide line 8 by line 9 and round the result up to the nearest whole number. Enter the result on line 10. This is the minimum number of DASD arms required for the selected system, hardware configuration, and workload.	10)	10) 14

Table 21 - Model 170 CPW and Arm Factors

Processor Feature	**Processor CPW**	**Interactive CPW**	**Arm Factors by Workload**			
			Interactive	**Server - Light**	**Server - Mixed**	**Server - Heavy**
2388	1090	70	15 (See note 1)	57 (See note 1)	See note 1	See note 1
2386	460	70	13 (See note 1)	46 (See note 1)	See note 1	See note 1
2385	460	50	13 (See note 1)	46 (See note 1)	See note 1	See note 1
2292	220	30	10 (See note 1)	44 (See note 1)	See note 1	See note 1
2291	115	25	10	38	16	10
2290	73	20	10	37	16	10
2289	50	15	8	25	12	8
2183	319	67	11 (See note 1)	64 (See note 1)	See note 1	See note 1
2176	319	40	11 (See note 1)	64 (See note 1)	See note 1	See note 1
2164	210	29	10 (See note 1)	42 (See note 1)	See note 1	See note 1
2160	114	23	11	38	17	11
2159	73	16	10	36	16	10

Notes:

1. This system is limited to a maximum of 10 DASD arms. This number is insufficient to support either a heavy server workload or an interactive workload using the full capabilities of the CPU. If using the MFIOP/9728, only 4 disk arms are supported. With only 4 arms, only VERY light DASD load applications are supported with full CPU power.
2. Four arms are required for the minimum RAID-5 protected configuration.

Minimum DASD Arms Required for Performance
AS/400 Model **6x0/5x0/4x0**

In order to determine the number of disk arms needed for optimum performance for an AS/400 Model 6x0/5x0/4x0, follow the instructions in the worksheet below. The results are for a specific benchmark @ 70% CPU Utilization. Your application may produce a different system load.

Worksheet for Model 6X0/5X0/4X0 Minimum DASD Arms required for performance		Example: Model 650-2243, 6533 IOP, 6613 DASD, RAID-5
1. In Table 22, find the processor feature for the desired model. Enter the corresponding base arms required on line 1.	1)	1) 214
2. In Table 1 on page 13, find the hardware adjustment factor corresponding to the IOP, DASD device, and protection method to be used. Enter the number on line 2.	2)	2) 1.04
3. Divide line 1 by line 2 and round the result up to the nearest whole number. Enter the result on line 3. This is the minimum number of DASD arms required for the selected system, hardware configuration, and workload.	3)	3) 206

Table 22 - Model 6x0/5x0/4x0 Base Arms Required

Model/ Processor Feature		Base Arms Required		Model/ Processor Feature		Base Arms Required
650	**2189**	322		**530**	**2162**	47
	2188	223			**2153**	41
	2243	214			**2152**	25
	2240	157			**2151**	19
640	**2239**	79			**2150**	15
	2238	41		**510**	**2144**	11
	2237	30			**2143**	8
620	**2182**	34		**500**	**2142**	5 (See Note 2)
	2181	21			**2141**	4 (See Note 2)
	2180	11			**2140**	3 (See Note 2)
	2179	8		**400**	**2133**	5 (See Note 2)
	2175	5			**2132**	4 (See Note 2)
600	**2136**	8 (See Note 3)			**2131**	3 (See Note 2)
	2135	5			**2130**	2 (See Note 2)
	2134	4				
	2129	3				

Notes:

1. Minimum RAID-5 protected configuration is 4 DASD devices.
2. For systems with 65x2 IOP, or 9337 4xx/59x models with 6501 IOP, the minimum configurable system is 6 DASD devices when using RAID-5, or 5 when using no protection. The total includes minimum arms required for the MFIOP plus appropriate arms needed on the feature DASD IOP.
3. Disk arms limited to 5 when using MFIOP, 9728, or 6530 IOP. Using this IOP type with full CPU power, only VERY light DASD load applications are supported -- i.e. the DASD will potentially become a bottleneck.

Minimum DASD Arms Required for Performance
AS/400 **Sx0** Server Models

In order to determine the number of disk arms needed for optimum performance for AS/400 Sx0, Server Models, follow the instructions in the worksheet below. The results are for a specific benchmark @ 70% CPU Utilization. Your application may produce a different system load.
Note: Mixed Disk Load values are an example of 50% Light Load plus 50% Heavy Load. Use the actual percentages for your case when determining minimum arms for the Mixed environment. (See introductory text for details).

Worksheet for Sx0 Server Models Minimum DASD Arms required for performance		Example: Model S30-2259, heavy server workload, 6533 IOP, 6707 DASD, RAID-5
1. In Table 23, find the processor feature for the desired model. Enter the corresponding processor CPW on line 1.	1)	1) 998.6
2. In Table 23, find the Interactive CPW for the desired model. Enter it on line 2. If system does not run interactive workloads, see the discussion of Interactive Features on page 12.	2)	2) 64
3. Subtract line 2 from line 1. Enter the result on line 3. This is the CPW available for server workloads.	3)	3) 934.6
4. In Table 23, for the desired model, find the arm factor for interactive workloads. Enter the value on line 4.	4)	4) 10
5. In Table 23, for the desired model, find the arm factor for the appropriate server workload. Enter the value on line 5. See the introductory material for more information on workload concepts.	5)	5) 10
6. Divide line 2 by line 4. Enter the result on line 6. This is the unadjusted number of arms required to support the interactive workload on a base MFIOP.	6)	6) 6.4
7. Divide line 3 by line 5. Enter the result on line 7. This is the unadjusted number of arms required to support the server workload on a base MFIOP.	7)	7) 93.5
8. Add lines 6 and 7, and enter the result on line 8. This is the total unadjusted number of arms.	8)	8) 99.9
9. In Table 1 on page 13, find the hardware adjustment factor corresponding to the IOP, DASD device, and protection method to be used. Enter the number on line 9.	9)	9) 1.04
10. Divide line 8 by line 9 and round the result up to the nearest whole number. Enter the result on line 10. This is the minimum number of DASD arms required for the selected system, hardware configuration, and workload.	10)	10) 97

Table 23 - Model Sx0 CPW and Arm Factors

Model/ Processor Feature	Processor CPW	Interactive CPW	Arm Factors by Workload			
			Interactive	Server - Light	Server - Mixed	Server - Heavy
S40	4450	120	14	71	24	14
2207	3660	120	17	81	27	17
2261	2340	64	15	73	25	15
2256	1794	64	11	56	19	11
S30	1794	64	11	56	19	11
2259	998.6	64	10	48	16	10
2258	583.3	64	11	53	18	11
2257	319	51.5	11	53	18	11
S20	759	56.9	10	47	16	10
2165	464.3	49.7	10	52	17	10
2163	210	35.8	10	42	16	10
2161	113.8	31	10	38	16	10
S10	73.1	24.4	10	24	14	10
2118	45.4	16.2	9	23	13	9

Notes:

1. Minimum RAID-5 protected configuration is 4 DASD devices.

Minimum DASD Arms Required for Performance
AS/400 **Custom Server** Models

In order to determine the number of disk arms needed for optimum performance for an AS/400 Model 740, follow the instructions in the worksheet below. The results are for a specific benchmark @ 70% CPU Utilization. Your application may produce a different system load.
Note: Mixed Disk Load values are an example of 50% Light Load plus 50% Heavy Load. Use the actual percentages for your case when determining minimum arms for the Mixed environment. (See introductory text for details).

Worksheet for Custom Server Models Minimum DASD Arms required for performance		Example: Model S30-2320, light server workload, 6533 IOP, 6707 DASD, mirroring
1. In Table 24, find the processor feature for the desired model. Enter the corresponding processor CPW on line 1.	1)	1) 998.6
2. In Table 24, find the Interactive CPW for the desired model. Enter it on line 2. If system does not run interactive workloads, see the discussion of Interactive Features on page 12.	2)	2) 215.1
3. Subtract line 2 from line 1. Enter the result on line 3. This is the CPW available for server workloads.	3)	3) 783.5
4. In Table 24, for the desired model, find the arm factor for interactive workloads. Enter the value on line 4.	4)	4) 10
5. In Table 24, for the desired model, find the arm factor for the appropriate server workload. Enter the value on line 5. See the introductory material for more information on workload concepts.	5)	5) 43
6. Divide line 2 by line 4. Enter the result on line 6. This is the unadjusted number of arms required to support the interactive workload on a base MFIOP.	6)	6) 21.5
7. Divide line 3 by line 5. Enter the result on line 7. This is the unadjusted number of arms required to support the server workload on a base MFIOP.	7)	7) 18.2
8. Add lines 6 and 7, and enter the result on line 8. This is the total unadjusted number of arms.	8)	8) 39.7
9. In Table 1 on page 13, find the hardware adjustment factor corresponding to the IOP, DASD device, and protection method to be used. Enter the number on line 9.	9)	9) 1.04
10. Divide line 8 by line 9 and round the result up to the nearest whole number. Enter the result on line 10. This is the minimum number of DASD arms required for the selected system, hardware configuration, and workload.	10)	10) 39

Table 24 - Custom Server Model CPW and Arm Factors

Model/ Processor Feature		**Processor CPW**	**Interactive CPW**	**Arm Factors by Workload**			
				Interactive	**Server - Light**	**Server - Mixed**	**Server - Heavy**
S40	**2341**	4450	2050	14	36	20	14
	2340	3660	1050	17	57	26	17
S30	**2322**	1794	579.6	11	35	17	11
	2321	1794	386.4	11	53	19	11
	2320	998.6	215.1	10	43	16	10
S20	**2178**	759	221.4	10	33	15	10
	2177	759	110.7	10	47	16	10
SB1	**2312,2313, 2311, 2310**	Special Purpose model. Supports very light DASD load applications only. Limited to 4 DASD arms.					
SB2	**2315**	Special Purpose model. Supports very light DASD load applications only. Limited to 4 DASD arms.					
SB3	**2316**	Special Purpose model. Supports very light DASD load applications only. Limited to 6 DASD arms.					
	2318	Special Purpose model. Supports very light DASD load applications only. Limited to 8 DASD arms.					

Notes:

1. Minimum RAID-5 protected configuration is 4 DASD devices..

Minimum DASD Arms Required for Performance
AS/400 **5xS/4xS/150** Server Models

In order to determine the number of disk arms needed for optimum performance for an AS/400 5xS/4xS/150 Server Model, follow the instructions in the worksheet below. The results are for a specific benchmark @ 70% CPU Utilization. Your application may produce a different system load.
Note: Mixed Disk Load values are an example of 50% Light Load plus 50% Heavy Load. Use the actual percentages for your case when determining minimum arms for the Mixed environment. (See introductory text for details).

Worksheet for Server Models 5xS/4xS/150 Minimum DASD Arms required for performance		Example: Model 50S-2121, light server workload, 2741 IOP, 6707 DASD, RAID-5
1. In Table 25, find the processor feature for the desired model. Enter the corresponding processor CPW on line 1.	1)	1) 111.5
2. In Table 25, find the Interactive CPW for the desired model. Enter it on line 2. If system does not run interactive workloads, see the discussion of Interactive Features on page 12.	2)	2) 32.8
3. Subtract line 2 from line 1. Enter the result on line 3. This is the CPW available for server workloads.	3)	3) 78.7
4. In Table 25, for the desired model, find the arm factor for interactive workloads. Enter the value on line 4.	4)	4) 12
5. In Table 25, for the desired model, find the arm factor for the appropriate server workload. Enter the value on line 5. See the introductory material for more information on workload concepts.	5)	5) 28
6. Divide line 2 by line 4. Enter the result on line 6. This is the unadjusted number of arms required to support the interactive workload on a base MFIOP.	6)	6) 2.7
7. Divide line 3 by line 5. Enter the result on line 7. This is the unadjusted number of arms required to support the server workload on a base MFIOP.	7)	7) 2.8
8. Add lines 6 and 7, and enter the result on line 8. This is the total unadjusted number of arms.	8)	8) 5.5
9. In Table 1 on page 13, find the hardware adjustment factor corresponding to the IOP, DASD device, and protection method to be used. Enter the number on line 9.	9)	9) 1.04
10. Divide line 8 by line 9 and round the result up to the nearest whole number. Enter the result on line 10. This is the minimum number of DASD arms required for the selected system, hardware configuration, and workload.	10)	10) **6**

Table 25 - Server Model 5xS/4xS/150 CPW and Arm Factors

Model/ Processor Feature		**Processor CPW**	**Interactive CPW**	**Arm Factors by Workload**			
				Interactive	**Server - Light**	**Server - Mixed**	**Server - Heavy**
53S	**2157**	650.0	32.8	10	50	17	10
	2156	598.0	32.8	11	54	18	11
	2155	319.0	32.8	10	46	16	10
	2154	188.2	32.8	10	47	17	10
50S	**2122**	138.0	32.8	11	35	17	11
	2121	111.5	32.8	11	28	16	11
	2120	81.6	22.5	10	27	14	10
40S	**2112**	91.0	32.2	9	23	13	9
	2111	63.0	21.6	9	21	12	9
	2110	35.0	14.5	7	18	10	7
	2109	27.0	9.4	7	14	9	7
150	**2270**	35	20.6	12	12	N/A	N/A
	2269	27	13.8	14	14	N/A	N/A

Notes:

1. Minimum RAID-5 protected configuration is 4 DASD devices.

Additional performance information and tuning suggestions are available in the IBM AS/400 V4R5 Performance Capabilities Reference Guide (340+ pages, 1.5MB Adobe Acrobat format) on the internet at: http://publib.boulder.ibm.com/pubs/html/as400/online/chgfrm.htm

Questions relating to the information in this document should be directed to Larry Whitley, ldw@us.ibm.com, Jason Clegg, jac@us.ibm.com, or Richard Odell, rjodell@us.ibm.com.