Examing the Duplication of Flight Test Data Centers

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ABSTRACT
Aircraft flight test data processing began with on site data analysis from the very first aircraft design. This method of analyzing flight data continued from the early 1900’s to the present day. Today each new aircraft program builds a separate data center for post flight processing (PFP) to include operations, system administration, and management. Flight Test Engineers (FTE) are relocated from geographical areas to ramp up the manpower needed to analyze the PFP data center products and when the first phase of aircraft design and development is completed the FTE headcount is reduced with the FTE either relocated to another program or the FTE finds other employment. This paper is a condensed form of the research conducted by the author on how the methodology of continuing to build PFP data centers cost the aircraft company millions of dollars in development and millions of dollars on relocation plus relocation stress effects on FTE which can hinder productivity. This method of PFP data center development can be avoided by the consolidation of PFP data centers using present technology.

INTRODUCTION
Each new military aircraft development contract awarded results in one or more sites created to flight test the aircraft. One major effect of duplication is the redundant cost of PFP data center development. Another major effect is the cost to employers due to engineer relocation stress when engineers are moved from one geographical location to the test site only to relocate to another flight test program site once the emphasis on the program diminishes. This research
studied the degree of both effects. Current technology was examined to determine if a method of PFP data center consolidation is possible which could change this convention of development whereby reducing the cost effect of engineer production loss and PFP data center development cost.

BACKGROUND

History

Data analysis at the site of the flight test program was practiced by the Wright brothers with hand written notes containing flight performance information studied after the test flight. This method of data analysis was the first form of post-flight data processing (Donald Giadrosich, 1995). Lack of technology prevented real time analysis during aircraft flight. After World War II the United States Defense Department approached EMR Inc. to design a frequency modulated method of remotely measuring aircraft data. The design was completed and EMR constructed a telemetry station at the site of an aircraft test program. Telemetry allowed analyzing flight data from a remote location during aircraft flight and was a means to eliminate dependence on pilot notes. The new technology of telemetry was not immediately popular due to lack of technical documentation (Strock, 1983) and aircraft companies continued to rely on pilot inscribed notes of flight characteristics into the 1950’s.

One hundred years after the Wright brothers the Wrights theory of on-site PFP has not changed. PFP systems are designed and based on the type of flight data to be analyzed and the methods created for use of the system argued Smith and Matthews (1981). This statement continues the theory of separate PFP development and operation at each test site. The basis for this theory is not completely true as all telemetry processing systems have portions of their design that are common. Strock (1983) wrote that every customer has unique requirements to process flight test data and the system design always contains basic portions which are common with other flight test data systems. Figure 1 illustrates the conventional thinking of duplicating flight test data centers and the implications.
The implications of this model are the continual duplication of:
1. Databases
2. Tape backups
3. Data processing engineers
4. System administration engineers
5. Data base administration engineers
6. Company paid schooling for system and database administrators
7. System development time, resources, and labor
8. System licenses, hardware and software purchases.
9. Data processing managers and supervisors
10. FTE located at each data center
11. Data center facility

FTE relocations

The importance of the first test phase forces the aircraft company to relocate FTE from other programs so flight data from the PFP data center can be analyzed. After a period of three to five
years the amount of FTE is reduced. The Chief Engineer for a major aircraft test program indicated the beginning engineering level was 200 FTE. After the first phase the Chief Engineer places the number of FTE at 20 which is only one tenth of the original number of FTE. Past researchers have researched multiple employee relocations on people from different geographical areas and occupations and the research showed a detrimental effect on the employee and their families (Anderson & Stark, 1988) and (Manion & Rantz, 1995). These severe effects due to high stress are listed by Anderson and Stark (1988) as depression, health deterioration, and divorce and identified as Relocation Stress Syndrome (RSS). FTE moving from location to location following flight test programs could possibly experience the same effects throughout their flight test career as a result of high stress.

**METHODOLOGY**

*Instruments*

Relocation stress on the FTE was measured using Cohen’s ten questions Perceived Stress Scale (PSS). This survey is a validated method of stress measurement used by imperial research on stress. The form of research was Formal Study using qualitative questions as no questions generated additional questions. Participants selected were at flight test sites in the United States. A pretest was given first to establish a baseline before relocation and the same questions given a second time to establish the stress level during relocation. Cost of data center development was entered into a standard two column table.

*Data gathering*

Stress data gathered was collected using face-to-face interviews, email and web access. Protection for participants responding to the stress instrument was coded labels instead of participant names. The coding was acronyms followed by incrementing integers

**RESULTS**

*Development expenses resulting from duplication*

The redundancy in purchasing software and hardware in addition to development time was exposed by Hughes, Gardner, and Painter (1996). The authors added to this redundancy the cost of processing the flight data. Smith and Matthews (1981) writings presented how 40 percent of the flight test budget is dedicated to flight test data processing. These statements are validated from literature showing the results of Air Force Budget Items in years 1999, 2005, 2006 and Business Services Industry in year 2000 identifying cost for flight test data processing. Table 1 reveals the budgeted costs during these years. Literature by Giadrosich (1995) added to this the cost of end of life disposition for the data processing system.

<table>
<thead>
<tr>
<th>Source</th>
<th>Year</th>
<th>Budgeted Amount</th>
</tr>
</thead>
<tbody>
<tr>
<td>Air Force Budget Item</td>
<td>1999</td>
<td>$2,625,000</td>
</tr>
</tbody>
</table>
Table 1

Data from 31 separate costs taken from vendor packaging lists were collected by this author as a partial example of amounts spent on data center development. These costs are presented in Figure 2 and span the years from 1995 to 2010.

![Costs Graph](image)

**Figure 2, Data Center Expenditures**

*Relocation expenses*

Relocations expenses paid by the employer can add to the expense of supporting multiple data centers. The cost of multiple relocations per engineer is shown in Figure 3 with a median of $38,000 per relocation during the year 2003. This amount is calculated using the minimum figure of $26,000 and maximum of $50,000 reported by Shinkly for relocation expenses in the year 2003. The medium amount is projected over 10 relocations at a peak of $450,000.

Medium = (26,000 + 50,000) / 2

Medium = $38,000

<table>
<thead>
<tr>
<th>Business Services Industry</th>
<th>2000</th>
<th>&gt;$1,000,000</th>
</tr>
</thead>
<tbody>
<tr>
<td>Air Force Budget Item</td>
<td>2005</td>
<td>$3,484,000</td>
</tr>
<tr>
<td>Air Force Budget Item</td>
<td>2006</td>
<td>$3,056,000</td>
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The average stress level recorded by Cohen’s research was 12.9. The author’s research on the FTE recorded an average of 13.0 before relocation. Table 2 shows how the median stress during relocation was 18. Peak levels of stress were recorded at 27. Imperial research shows how the employer can lose six months of employee productivity with high levels of stress. Average career years of participants were two with a maximum of 40. Relocations were a minimum of one to a peak of 21.

### FTE Stress level

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<table>
<thead>
<tr>
<th>Statistics</th>
<th>1st stress level</th>
<th>2nd stress level</th>
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<tbody>
<tr>
<td>N</td>
<td>Valid 35</td>
<td>Valid 35</td>
</tr>
<tr>
<td></td>
<td>Missing 0</td>
<td>Missing 0</td>
</tr>
<tr>
<td>Median</td>
<td>13.00</td>
<td>18.00</td>
</tr>
<tr>
<td>Minimum</td>
<td>7</td>
<td>7</td>
</tr>
<tr>
<td>Maximum</td>
<td>21</td>
<td>27</td>
</tr>
</tbody>
</table>

Table 2, Stress levels on FTE
A CONSOLIDATED MODEL

Centralizing a flight test data centers is possible and proposed using today’s technology. A central location can accommodate one large PFP data center capable of processing all data from numerous aircraft programs. One group of FTEs can support multiple aircraft programs without relocating their homes and families to another geographical location. Data operators support all programs and are not dedicated to one program. When aircraft programs go into production and flight testing priority decreases the FTE is simply given tasks to analyze data from another program avoiding relocation. Data processing uses virtual systems by movement of aircraft processing to other hardware during system upgrades or failures. Legacy systems can be reloaded anytime in the future to process stored data from programs shutdown in the past. The data processing departments can concentrate system administration to only the processing systems. Databases, database servers, offset backups, network maintenance and disk storage requirements move into the responsibility of the corporate IT Company relieving the data processing department of funding schooling, extra manpower and many software licenses. Each test site retains a group of FTE for safety of flight during aircraft testing. Instrumentation engineers and engineers supplying real time data upload the aircraft test data over a virtual private network to a data mart within a data warehouse corresponding to the aircraft program generating the test data. Data operators process this data and store the derived data at the same data storage site. Database servers can run multiple instances of Oracle to support each aircraft program. Offsite backup can be performed at a central location. Tape backups can be located anyplace geographically. All users are given access by program authority to required program data. Figure 4 models a consolidated methodology.
Figure 4, Proposed Model of Development
SUMMARY

Data center development for flight test today is by convention established during the days of the Wright brothers. Technology exists to consolidate this method yet no attempt is made to move towards consolidation. Enterprises have either consolidate or duplicated their data centers based on current technology and today the effort of enterprises is to consolidate. Literature research shows opposing theories on consolidation since the 1980s by Smith & Matthews and Van Der Velde with theories on consolidation by Strock and Weaver. Today both of these theories are held. This author’s research shows the present methodology of flight test data center duplication has become a convention. The result is high stress on FTE due to relocations with the possibility of loss productivity and family problems. Millions of dollars are going into operation of development and operation of multiple data centers.

REFERENCES


