The VIPER Experience

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Abstract

This paper discusses the evolution of VIPER into a fully-fledged, commercial project control system that uses Earned Value as its core progress reporting system. VIPER is designed to optimise repetitive project cycles (in this case, aircraft maintenance and repair programs) in a data rich environment[1].

Business and project communities are facing a number of contradictory pressures:

- The downsizing and deskilling of their work forces, particularly in the technical support and middle management areas.
- The increase in litigation and lack of tolerance towards any delays, processing errors and/or omissions.
- The need to be ever more efficient with reduced project budgets and shorter timeframes.
- The increasing complexity of many projects and project systems.

The combination of these factors is creating pressures on business systems (with particular reference to project control systems) to deliver enhanced efficiency and process integrity whilst minimising risks.

During the heyday of project management software development (in the 1970s and 80s), it was "normal" for businesses to employ project and senior schedulers in permanent well-paid positions and to maintain staffing continuity within their businesses technical and administrative areas. This structure allowed staff to develop deep domain knowledge and to "know", just by looking, when something was incorrect or missing (as well as having the resources to correct the problem).

In the leaner, meaner environment of the 21st century, these luxuries are no longer possible. Systems need to be designed with the prudential checks and balances that experienced staff used to be able to provide, incorporated as an intrinsic part of their overall processes (as well as being super efficient).

The VIPER system is used to manage and schedule aircraft deep level maintenance programs for the ADF and a number of commercial businesses. VIPER integrates maintenance data, timesheet data, hangar floor reports and project scheduling using a number of data integration, management and automated capture processes, which has in effect created an "expert" system. Since its introduction, VIPER has generated cost savings in excess of 30% to the ADF deep level maintenance programs.

The approach embodied in VIPER allows project control systems to be designed utilising the most effective components (Scheduling, MRP, Timesheet, Data management, Accounting, etc) and then to integrate the data capture, information flows and analysis to ensure prudential processes are mandated whilst optimising the overall efficiency of the business unit.

The evolution of VIPER has also provided valuable insights into the way carefully structured information flows can influence business outcomes. These "lessons learned" are applicable to many processes and are discussed in detail at the conclusion of the paper.

The Requirement for, and Evolution of, VIPER

Business Pressures in the 21st Century

A combination of factors is creating pressures on business systems (with particular reference to project control systems) to deliver enhanced efficiency and process integrity whilst minimising the opportunity for errors. These drivers include:

- The downsizing and deskilling of the businesses work force[2].
- The increase in litigation and lack of tolerance towards any delays, processing errors and/or omissions.
- Reduced project budgets and ever shorter delivery timeframes[3].
- The increasing complexity of many projects and project systems.

The solution sought by businesses to overcome these problems is to look for systems that deliver accurate prudential processes, enhanced efficiency and improved outcomes whilst being quick to implement, and are cheap and easy use. An interesting (but not impossible) challenge!

People Issues[2]

The trends towards "down-sizing" and out sourcing prevalent in most businesses has had its greatest impact in the area of in-house technical and engineering support roles. Businesses no longer employ engineers and technocrats in career positions to provide internal skills and support to systems and projects. One impact of removing this layer of expertise has been to reduce or eliminate an organisations capacity to "know" when something is wrong simply by someone looking at it and getting a "gut feeling" something is not right. Another impact has been to severely restrict an organisations ability to develop and maintain complex system and procedures from within its own resources.

Career advancement in this environment is often via achieving success in series of projects rather than a steady progression of appointments within a 'discipline'. This creates managers who are skilled in the arts of problem solving and project delivery but who often lack the broad depth of generic knowledge gained by a professional who's career developed within a specific discipline.

The reduction in staffing levels has also created far greater mobility. People are moved from one project to the next as soon as they have some spare capacity to fill "urgent" needs and the rate of staff turnover has increased significantly as organisations poach qualified staff and individuals seek career advancement. From a systems maintenance viewpoint, vital knowledge walks out of the door every time a staff member is transferred or leaves. This loss of knowledge is compounded by a noticeable reduction in the time allowed for training.

Employing external contractors and consultants is an effective option to fill the skills and knowledge gap for the development of a specific project or process, but this is not a practical solution for long term routine input to core business functions. As a consequence, the responsibility for dealing with the issues that experienced staff in relatively long term carer positions supporting technical systems used to know how to manage has been transferred to "intelligence" built into the system its-self.

Reduction in Training Budgets

Formal training budgets are lower and informal on-the-job training and effective "hand-over" periods have been severely curtailed by the work pressures caused by reduced staffing levels. Whilst arguably these are false economies, they are also a reality of 21st century business.

Following the implementation of a "new" system, local management is typically faced with the need to keep their businesses running whilst operating with reduced staffing levels (after all, the new system offers increased efficiencies). When these pressures are coupled with "learning curve" issues, the allocation of resources to formal classroom training process becomes virtually impossible

The pressure on budgets compounds this problem. During purchasing negotiations for any new system, one of the easiest items to cut (or reduce) is the formal training component – there is no immediate or obvious loss of functionality (the problems come later!).

The result is the expectation on the part of business that their new system will be easy to use, obvious to use and have built in checks and balances to prevent wrong actions and decisions by staff (ie the system itself will teach the staff how to use it). This expectation is to say the least difficult to achieve, particularly when the needs of experienced users -v- the need of first time users are considered.

Careful system design and a user-friendly architecture helps. Other responses being incorporated into the VIPER package include:

- Beefing up the traditional 'help-desk' and vendor support functions built into the purchase price of a new system.
- Obtaining and maintaining a very high level of domain expertise within the vendor organisation so that support, training and assistance is explicitly tailored to the clients requirements (thereby creating a true partnership).

- Ensuring supporting documentation is user-centric (manuals, etc).
- Restructuring training delivery to minimise extended classroom sessions.

General Business Pressures[3]

At the same time down-sizing has been reducing a businesses people-based capability to respond to complex project requirements, the general market has been ramping up pressures to produce more complex projects, for lower costs, in less time. The expected "time to market" is less. Products are more complex as are contractual requirements and supply arrangements. The response to these pressures has been for businesses to rely on sophisticated systems and software (ERP, Supply Chain Management, etc) to replace (and improve on) the people-based capabilities of the past. For this strategy to succeed, the systems must be capable of learning and adapting to improved work practices as a normal part of their routine operation.

Legal Issues

In parallel with increasing business pressures, organisations are facing increased legal pressures to conform to strict contractual requirements, eliminate delays, eliminate process errors and avoid "mistakes". When errors occur, negligence and indemnity claims are more likely and the amount claimed is tends to be significantly higher than in the past.

Again, the response of businesses has been to rely on sophisticated systems to ensure prudential processes are followed and risks minimised. However, for a system to be effective in this role, not only must the prudential processes be incorporated within it, but it must also be easy to use (to avoid operator error) and most importantly, actually used.

The IT Response – Monolithic Systems

The response of the IT industry to these challenges has been to develop monolithic systems. Typically, these systems have one or more core competencies and a number of peripheral modules spanning the whole business spectrum. A typical example would be SAP, its accounting modules are (in the author's opinion) world class, however, SAP's project management module lacks much of the ease of use and functionality found in professional project management systems.

Monolithic systems tend to be expensive to buy, expensive to deploy and both expensive and difficult to change. People with the requisite skills to develop and maintain them are in short supply, expensive and mobile (both internally and externally).

The monolithic nature of these systems with their focus on total integration is also at times less than ideal. The integrated nature of their data structure makes playing "what-if" scenarios difficult and the need to maintain data integrity often compromises ease of use in (from the systems point of view) peripheral areas.

Suggested Alternative Approach

An alternative approach to deploying a "one size fits all" monolithic system across all areas of a business is to restrict the "big" system to the areas of its core competency and use "best of breed" components to support it and the business in the other areas. Designing the data management processes to integrate and control the flow of information between these components is a complex and difficult process but when implemented successfully can deliver significant overall cost savings and benefits to a business. VIPER is such a system and provides an excellent example of the cost savings and benefits to be derived from developing sophisticated integrated systems.

The Evolution of VIPER

Commercial VIPER is the result of 15 years of development. The initial systems were developed under the auspices of Australian Defence Force (ADF) managers as they sought to respond to some of the business pressures outlined above. More recently, the drivers for VIPER enhancements have come from a combination of ADF and commercial managers seeking to reduce the cost and optimise the maintenance of ADF air assets.

VIPER is not the result of some sudden "flash" of inspiration, nor was the final form of the system foreseen during the early stages of development. Each change in process and its supporting technology was driven by real needs and issues at that time. Then, as the new "enhanced" processes were rolled out, new expectations were created, new issues and problems recognised and new opportunities identified.

VIPER is an adaptive or evolving system.

In the beginning[5]...

Prior to the introduction of computer based scheduling systems, the RAAF used a PERV (Planned Event Recurring Visually) board to manage each servicing[1]. This was a metal board with each task described on a magnetic strip. A typical scale was 50mm = 4 Hrs, consequently 10 meter long PERV boards were not uncommon!

Different types of work were identified by the use of different colour strips. The different phases of a typical servicing shown on the PERV boards (Preparation, Teardown, Inspection, Rectification, Rebuild/Refit, Functional Testing) are still a fundamental part of the architecture of VIPER's maintenance schedule.

Progress was indicated by a cursor that was moved along daily. Incomplete work was kept in front of the cursor, finished work moved behind. A typical servicing would have over 3000 magnetic strips to keep adjusting.

There were three key problems identified in the use of the PERV system:

- The boards we cumbersome and labour intensive to maintain.
- There was no logical relationships defined between jobs, allowing people on the hangar floor a significant degree of freedom to pick and choose the work they would do on a day.
- There was very little management information to assist in the effective control of the overall servicing schedule and manage the significant changes in workload caused by the inspection/rectification process.

Aircraft Servicing Planning System (ASPS)[4]

ASPS was developed to computerise the scheduling processes prototyped on the PERV boards and rectify the key problems identified above. As with most innovative systems, the initial impetuous came from an individual frustrated with the current system

In the case of ASPS, a Warrant Officer working at Amberley airforce base met the author of this paper at an Apple Computer show in 1987. He saw the possibilities of using project management software to deliver significant additional management benefits whilst at the same time removing many of the limitations of the PERV system. ADF management and the author's business quickly agreed to an initial trail and ASPS was born.

The development of ASPS as an overall process took a couple of years and was supported by the innovative approach adopted by a RAAF workstudy team engaged in developing improved maintenance work practices. A typical "roll out" of ASPS would involve the workstudy team and base management designing a new "master schedule" containing optimum task durations and dependencies. Initially these schedules only contained the "known" work, later the schedules were modified to include provision for the "unknown" (but expected) rectification work that would be identified during the inspection phase of each aircraft servicing.

As with the PERV system, a typical schedule could easily exceed 3000+ tasks divided into a number of subprojects. The current schedule was displayed (as a set of logic diagrams) on a hangar wall or a set of large A-Frames near each aircraft.

The processes for defining the works to be undertaken and signing off on completed works remained unchanged from the PERV system using a combination of Servicing Cards, Special Instructions and EE 508 forms.

ASPS – Managing Unscheduled Rectification Works

The efficient management of rectification works is a key element in the effective management of an aircraft servicing. Rectifications and repairs can account for up to 50% of the total effort committed to a servicing. ASPS was the first system to implement formal processes to effectively schedule this aspect of the work.

An example of the potential for major changes is to look at the consequences of a "failed" Non Destructive Inspection (NDI) of an engine mount on the wing of a P3 Orion aircraft. The 20 minute NDI task would be scheduled in the Inspection phase of the servicing, after the panels and heat shields had been removed for access. If the inspection revealed some cracking, the whole mounting may need replacing.

To replace an engine mount, removal of the engine, disconnection of electrical looms, fire wires and fire extinguisher systems would be required. If the mount fasteners go into a fuel tank, fuel access will be required, involving the purging of flammable vapours for safe access. If a lot of fasteners need to be removed, further trestling of the wing or an alignment jig may be required to prevent movement.

Once the mount and fasteners have been replaced, the inside of the fuel tank would have to be sealed, the sealant cured and the tank checked for leaks later on. Additional functional testing of other engine systems may also be required. A simple 20 minute inspection has expanded to several hundred hours of work involving several trades, specialist equipment and the disruption of work on other tasks.

ASPS introduced the concept of **N**etwork **U**pdate **P**roformas (NUPs). NUPs were used by the tradesperson to tell the schedulers where the new task(s) needed to undertake a repair could be fitted into the current schedule. The tradesperson would complete the NUP form with reference to the existing schedule, the expected duration of the task(s) and the required resources. When complete, the NUP would be submitted to the Maintenance Control Section (MCS) who would add the task(s) to the schedule. In addition to the NUP, the tradesperson also had to fill in and sign off an EE508 as an official record of the repair. One key advantage of this process was the direct involvement of the workers undertaking the servicing with the overall scheduling process. However, at the height of the inspection phase of a servicing, up to 150 new repair tasks could be added to the schedule every day!!

ASPS – The Successes

In many respects, ASPS was an outstanding success. The introduction of ASPS at No 3 Aircraft Depot (3AD – Now 501 Wing), Amberley in 1988/1989 is recorded as having achieved the following[3]:

- Introducing the concept of resource levelling and 'Critical Path Scheduling' to ADF aircraft maintenance processes
- The Reduction of an R5 (deep level) servicing on an R/F111 from 44 weeks with 5000 Hrs of overtime to 24 weeks with 500 Hrs of overtime
- The Defence Productivity Award in 1990
- Savings of $4.98 million by July 1991

Following the success of ASPS in generating savings both in maintenance resources and aircraft availability, its use was mandated for all ADF aircraft on servicings exceeding 10 days duration.

The use of ASPS had varying levels of success and acceptance at other bases. At Edinburgh (SA), the resource scheduling capabilities of ASPS proved the need for more people and the requirement for an additional hangar. In other locations the lack of effective change management processes, training and support gave rise to both acceptance and operational problems and in some cases a "them and us" attitude verging on hostility between the hangar floor and the MCS section.

ASPS – The Problems

The following shortcomings were identified in ASPS[3]

- The physical size and complexity of an ASPS schedule with over 3500 tasks required for a typical deep level maintenance program needed both a high level of operator skills and a significant level of effort to keep the schedule maintained and accurate. But MCS staff were posted on a regular basis and not everyone is equally suited to the role of a planner.
- The ever-changing critical path (caused by the addition of NUPs to the schedule) was undesirable and difficult to manage.
- The resource scheduling process would sequence similar tasks across different zones whereas "common sense" suggested that a tradesperson should complete all of the similar tasks in one zone at the same time and then move onto the next.
- Only one aircraft could be scheduled at a time because of the size and complexity of each schedule. This effectively prevented the balancing of resources across the whole workload of a hangar (ie several aircraft)
- Continually changing completion dates caused by the progressive addition of repairs as they were identified.

- The lack of any direct correlation between the schedule tasks and the jobs listed in the various documents issued for the servicing. Data integrity was maintained between the different processes by labour intensive, manual checking.
- There was no direct correlation between EE 508s and NUPs
- The perceived "slow" reaction time of MCS sections in processing data and reprinting the schedules was seen as preventing the proactive management of issues, in many cases management preferred to remain reactive, sorting out problems on the hangar floor.

The first development of an enhanced system to mitigate these issues was HERMES.

HERMES[6]

Hercules **R**epair and **M**aintenance **E**ngineering **S**ystem (HERMES) was developed by the RAAF's 503 Wing (Richmond) working in conjunction with Fallon Project Management Pty Ltd[2] in 1994/1995 to resolve many of the identified issues and problems in the ASPS system.

HERMES introduced a FileMaker Pro database in front of the scheduling tool to organise and "package" information. This process significantly reduced and simplified the schedule and removed vast quantities of paper from the hangar floor.

Pre-HERMES Paperwork

The paperwork required to conduct a servicing included:

- The Servicing Record Certificate. This recorded all signatures of the tradespeople and inspectors working on the aircraft as well as aircraft and servicing information
- Normal Servicing Cards and Special Servicing Cards. These were only available in printed format, were very slow to be changed and reprinted and contained up to 3500 different tasks to be completed. The same task (eg remove a cover) could be repeated on several different cards, one dealing with an electrical inspection, one dealing with a hydraulic system check, structural inspections, etc.
- Special Servicing Instructions and Modifications. These describe additional tasks to be carried out as required (or instructed) during a servicing.
- Maintenance Worksheets. These describe components that are to be replaced or serviced during the servicing because they are life expired.
- Records of Unservicabilities and Component Change Forms. Every fault needing rectification on the aircraft needs recording on one of these forms and when the problem is rectified, the corrective actions are recorded.

Every task has to be signed for by the tradesperson doing the work and depending on the task, a supervisor's signature and an Independent Inspector's signature may be required.

All of this paper (often over 1200 separate sheets and/or cards) was issued to the hangar floor at the beginning of the servicing. A significant clerical effort was required towards the end of the servicing to locate all of the pieces of paper, check all of the signatures and ensure the servicing was actually 100% complete.

The HERMES Database

With the advent of HERMES, almost all of the servicing information was loaded into the HERMES database for both variants of the Hercules (C130E and C130H) and both levels of maintenance undertaken by 503 Wing (R3 and DLM servicings) as well as all Special Servicings, Technical Instructions and Modifications. This information was held as data, with every task in the database being pre-allocated to a "package" when the task is switched on (either by selection or as a function of the particular servicing) it is printed in that package for that particular servicing.

Depending on the aircraft being serviced and the nominated level of servicing, the appropriate maintenance tasks were automatically selected for inclusion in the servicing. Special Servicings, Technical Instructions and Modifications were switched on (or left switched off) as required or instructed by the aircraft operator and any known unservicabilities were added to appropriate repair packages by the MCS section based on information contained in the aircraft documentation.

HERMES and the Master Schedule

HERMES (and VIPER) have continued to use the concept of a 'Master Schedule' originally developed for ASPS. The 'Master Schedule' describes the best way of conducting a servicing based on learned experience. As work practices improve, the Master Schedule can be modified and updated to reflect the improved practices in all future servicings. The tasks in the Master Schedule represent the Packages in HERMES.

The major differences between a HERMES/VIPER schedule and the old ASPS schedule are the number of tasks. There are approximately 300+ packages in the new schedule (typically a package will have 10 to 15 jobs included within it) compared to the 3500+ tasks in the ASPS schedule. The other key difference is the inclusion of packages in the Master Schedule to cover the repair works expected to be found during the inspection processes.

HERMES "Packages"

The concept of "Packages" first used in HERMES and carried forward into VIPER has significantly simplified the paperwork needed to document a servicing. A package typically includes all of the work to be completed in a particular phase of a servicing, on a nominated part of an aircraft, by a trade. The package paperwork is printed and held in a plastic ring binder for ease of use. Packages are described in detail in the 'Key VIPER Processes' section below.

One of the major efficiencies delivered by HERMES was the reduction in time needed to deal with a servicings paperwork. The packages contained all of the necessary information and places for the work to be completely "signed off" on completion. Packages were issued progressively, to facilitate the progress of the works, based on the requirements of the critical path schedule. A package could not be returned as "complete" until all of the necessary signatures were attached. This made tracking the "sign off" process a progressive function that was dealt with as the servicing proceeded and as a consequence, eliminated the massive "paper chase" required at the end of an ASPS servicing.

HERMES NUPs

The role of NUPs changed significantly with the introduction of HERMES. NUPs are now a controlled document used to record and manage all unscheduled rectifications and transfer jobs between packages. Most NUPs are generated during the inspection phase of a servicing by the tradespeople doing the inspections; the NUPs are them passed to the MCS section where the repair work is allocated to the appropriate "repair" package. When the "repair" package is printed later, all of the identified jobs are included in the one document.

HERMES Management Control

The smaller, less changeable schedules developed for HERMES allowed major improvements in management information and schedule control. Changes to the base schedule were relatively rare (packages/tasks were already in the schedule for all normal repairs), therefore overall progress and trends could be noted during early updates and decisions made before any slippages became significant. A sudden increase in repair work in one section could be noted during the inspection phase (from the flow of NUPs) and resources redeployed appropriately. Also, the overall volume of work on a servicing could be monitored (against the norm) from very early in the servicing, again allowing timely management decisions.

The improved effectiveness of the HERMES scheduling system (allowing better management visibility and control) was made possible by transferring much of the data previously included in the ASPS schedule into the HERMES database. All of the information was still available when needed, it was simply removed from the resource scheduling process and more manageable, aggregate information used in place of the mass of detail.

HERMES – The successes

HERMES achieved another round of savings and increased efficiencies in the ADF's aircraft maintenance processes. Some of the benefits identified by 1995 included:

- An average reduction of 52% in the time required to complete R3 servicings.
- A reduction of 42% in a DLM servicing.
- A significant reduction of staff in the MCS section (compared to the ASPS requirements).
- Improved accuracy in predicting the dates spares or engineering decisions were required.
- Acceptance by the tradespeople, particularly of the "packaging" process which removed vast quantities of paper from the hangar floor.
- The ability of the system to "learn", thereby introducing the concept of continuous improvement into ADF work practices.
-

HERMES – The problems!!

The major problem with HERMES was its name. Other units were unwilling to consider a Hercules system for managing the maintenance of their aircraft! Many people genuinely doubted that a system developed for a transport aircraft could be used on (or was suitable for) sophisticated fighter aircraft.

VIPER[5]

Vertically **I**ntegrated **P**rogrammed **E**ngineering **R**epair (VIPER) was initiated as a project by Support Command in late 1995 to further develop HERMES and make it available to all RAAF maintenance units, most of whom were still using ASPS at that time.

The initial rollout was based on variants of HERMES customised to meet the requirements of individual units. Whilst the relatively quick deployment was an initial advantage, the large number of VIPER variants soon started to cause enhancement and maintenance problems.

A single unified system for the whole ADF, VIPER97, was released at the end of 1997. This system has been progressively improved and enhanced based on management requirements and user feedback.

VIPER migrated from being an ADF exclusive system to a commercial system with the outsourcing of aircraft maintenance for the Hercules and F111 fleets to Qantas and Boeing respectively. The needs of commercial operators differ significantly in some key areas from the requirements of defence force management, and have caused a fresh round of system developments. VIPER8 (V8) was released in 2002 followed by V9 in 2003.

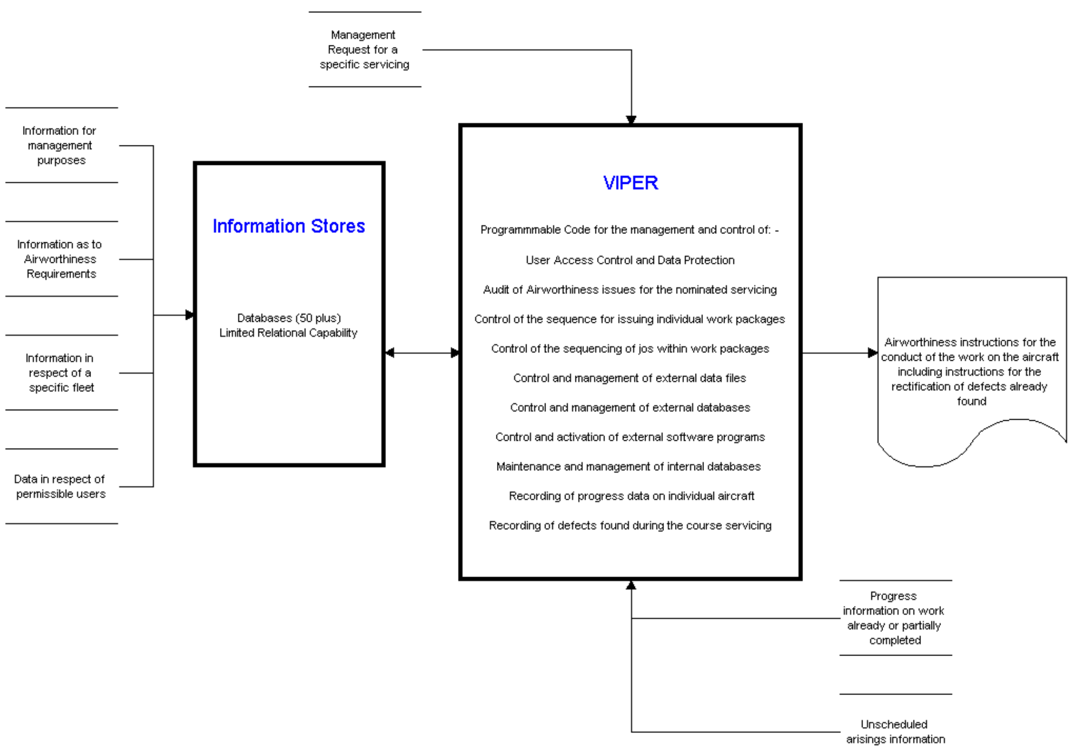
The balance of this paper will focus on these latest systems and the advantages to be gained from the effective integration of data management systems.

Current VIPER Functionality

VIPER is a complex system with a range of interlinked processes. Rather than attempt to describe the whole system in detail, a number of key processes (with application in the wider business community) will be discussed.

VIPER Overview

Figure 1 - VIPER Overview



VIPER performs the following functions and processes:

- It ensures the prudential management of the servicing data through to completion.

  VIPER is designed as a prudential management system with a significant and comprehensive series of internal checks and balances.

  New data sets provided by the aircraft owners for any particular level of maintenance can be checked, sorted and verified against previous data sets. VIPER can import, store and validate both COMPLAN (now largely redundant) and OMEGA2B[1] data. Its modular design can facilitate any other structured data import from other sources if required.

  All data (jobs) allocated to a servicing have a full audit trail, their origin, AL status, package allocation and completion are checked. Any unallocated jobs or incomplete packages generate error messages that require resolution before the servicing can be completed and the MCS must verify the servicing has completed in accordance with prescribed procedures and documentation. VIPER generates servicing reports during the servicing and post-servicing reports at the end of each servicing to assist in this audit function.

  Documentation of and verification that, each stage of the servicing is complete is a progressive and streamlined process assisting the final acceptance of the servicing by the aircraft owner.

- It facilitates the collection of all necessary maintenance data required prior to starting each aircraft servicing.

  There are a wide variety of data required to define each servicing's scope of work. These are provided by a number of sources at differing time prior to the induction of the aircraft. They may be in either electronic or hardcopy formats, or a combination of both. VIPER processes all of these data and prepares the servicing into an ordered and agreed sequence of packages. The VIPER system (provided there is no significant departure from the designated process) generates a documented audit trail to ensure that all aspects of the servicing have been executed.

- Core data are protected.

  VIPER is designed to protect all of the essential "airworthiness" data. Fallon Project Management can change some core data; other changes (particularly deletions) require special password access.

[1] The OMEGA2B and COMPLAN systems are the repository of all of the maintenance processes and instructions necessary to keep an aircraft type airworthy. The aircraft owner maintains a separate data set for each aircraft type. The latest version of the data for a particular level of servicing forms the baseline minimum work required to be completed to return the aircraft to service. OMEGA2B is progressively replacing COMPLAN within the ADF.

- It facilitates the design and sequencing of packages.

  Packages are defined in a 'Master Schedule'. This schedule captures the current best practice to deliver optimum servicing outcomes. As understanding and work practices improve, the Master Schedule can be modified and the new way of working is locked in for the future. The number, scope, description, duration, resource requirement and sequencing of the packages are defined in the Master Schedule.

  The Master Schedule forms the basis for each aircraft specific servicing. Individual servicings can then be modified, new packages added, resource levels adjusted, etc. as needed to accurately reflect the actual situation on a particular aircraft.

- It allows the management of operations within packages.

  The order of operations (jobs) within a package is designed by the system's users to give the optimum sequence of working.

  VIPER provides the flexibility of moving individual operations between packages or reordering operation within packages. There is also the option to create new packages or consolidate existing packages. This gives the flexibility to manage the contents of packages to improve efficiency and work flow. VIPER maintains the existing operation references for audit and tracking purposes.

- VIPER is an expert system.

  The grouping and sequencing of operations within packages may change depending on the servicing and any modifications, special servicings, MMIs, etc., required. An operation may be placed in different packages depending on whether the servicing is a R1, R2, R3, R4, R5, or Phased Servicings, etc.

  The VIPER system allows each user to develop its own sequencing to reflect its business' practices and procedures and retain that knowledge for all future servicings.

- VIPER's packaging facilitates best work practice and benchmarking.

  Maintenance activities need to be continuously reviewed to improve productivity. By starting with an established work practice (transferred into the VIPER system), operators can begin to review and improve productivity right from the first aircraft. This allows the management cycle (plan, monitor, review, and adjust packages/schedules) to commence earlier than would otherwise be the case thereby facilitating a higher starting point on the overall learning curve for the maintenance process.

- VIPER integrates scheduling functionality.

  The close coupling of a scheduling process with the maintenance data management processes allows the prioritising of packages based on a resource-levelled critical path schedule. This delivers new functionality and the optimum use of scarce resources to achieve the lowest practical completion time for each servicing, and for the whole hangar wide workforce.

From the scheduling process, VIPER generates a wide range of standard reports including:

- WBS Charts
- Gantt Charts (summary, detailed, selected, comparative)
- Milestone reports (target, actual, slippage, etc)
- Network Charts
- Earned Value Charts and reports

VIPER's coding structure allows filtering and sorting at many levels.

- Integration with downstream analysis tools

  The completion date for aircraft undergoing servicing and the average time to complete each level of servicing are key inputs to the FleetOPS Feet Management System developed by FPM. FleetOPS is designed to optimise the overall flying/maintenance cycle for a fleet of aircraft against known requirements and constraints. VIPER provides the key 'starting condition' for each analysis.

- Integration with Timesheet, MRP and other systems

  VIPER is designed to facilitate two-way data exchange with other key corporate systems. Aircraft specific package information can be groomed for, and exported to, MRP and timesheet systems for the collection of time and material costs based on the actual tasks being performed on the hangar floor.

  Packages can have barcodes included on the printed documents to facilitate "scanning" of key data such as the removal of components from store for fitting onto the aircraft or the clocking on and off workers for accurate time recording against specific tasks eg chargeable repair work.

  Actual 'cost' data gathered by the MRP system is then transferred to VIPER for use in Earned Value and progress reporting functions.

Key VIPER Processes

Developing and Maintaining the Master Schedule

Each task in the Master Schedule represents a "Package" of work to be undertaken on the aircraft. The Master Schedule is developed as a resource levelled critical path schedule in the planning tool where the description (scope) of each package is defined together with its duration and resource requirement. Once the schedule is optimised, this base data set is incorporated in the database, 'Task descriptions' become the 'Package name', task numbers a part of the package number, etc. Edits to the data can be made in the database or in the Master Schedule, variants of the Master Schedule are maintained for each level of servicing. The VIPER database holds all of the information needed to create a new servicing including a new aircraft specific schedule and the corresponding uniquely numbered packages.

To create a new servicing (comprising of a prime servicing and a number of secondary servicings), VIPER adds an identifier to the basic package number to create a unique number. The data necessary to create the specific schedule is then down loaded to the scheduling tool and a new servicing specific schedule is created and analysed.

Based on the schedule's sequence and timing, packages with the corresponding number and description are printed as needed for the conduct of the servicing. The printed package contains all of the additional information needed for the tradesperson to complete the task.

VIPER Packages - Content and Design

The concept of "Packages" first used in HERMES and carried forward into VIPER has significantly simplified the paperwork needed to document a servicing. A package typically includes all of the special and standard servicing tasks, component changes, modifications, etc required to be completed in a particular phase of a servicing on a nominated part of an aircraft by a trade (eg all of the avionics inspections on the left hand wing). It has a basic 3 digit number (eg 129) that is constant. This is augmented with aircraft specific data to create a unique number for that package on a particular servicing (eg 236C129 where 236 is the aircraft number, C is the Use On Code for the aircraft and 129 is the basic package number).

One of the key elements of the VIPER concept design is that as a general principle, the same package (number, description and scope) should always refer to the same element of work at the macro level. This allows a history of performance on the package to be built up over time and improves the VIPER operators/managers ability to refine future estimates and to recognise when something "unusual" is occurring during an aircraft servicing. This is not a mandatory requirement, the Master Schedule can be redesigned at any time, but it is important for developing the data history required for the long-term improvement of an installation's servicing delivery.

Not all packages contain the typical work described above. Some packages may include tasks that need a combination of trades to be completed efficiently. Repair packages are typically empty (with an estimated duration and resource requirement but no actual work) until rectification works are added during the inspection processes via the NUPs process. The design of VIPER gives users the flexibility to specify packages in a way that optimises the performance of their business.

The package paperwork is printed and held in a plastic ring binder for ease of use, it includes:

- Planned schedule and resource information (derived from the scheduling tool)

- Descriptions of the specific maintenance jobs to be completed as a part of the package, including references to any necessary technical instructions, manuals, etc.
- Places for all necessary signature requirements (both for each individual job and control of the overall package)
- Space for recording and signing off any minor repairs completed during the course of the work specified work on the package (pre-printed EE 508s)
- Barcodes for linking to MRP and Timesheet systems if required by the user

Any significant repairs identified during the performance of the work of the package are recorded on VIPER NUPs and processed into future (unprinted) packages. Most NUPs are generated during the performance of jobs in 'Inspection' packages but NUPs can be raised at any time as new repair works are identified. The grouping of maintenance jobs (NUPs) into Packages is optimised to create a practical task that one or two tradespeople can pick up and finish in a sensible timeframe.

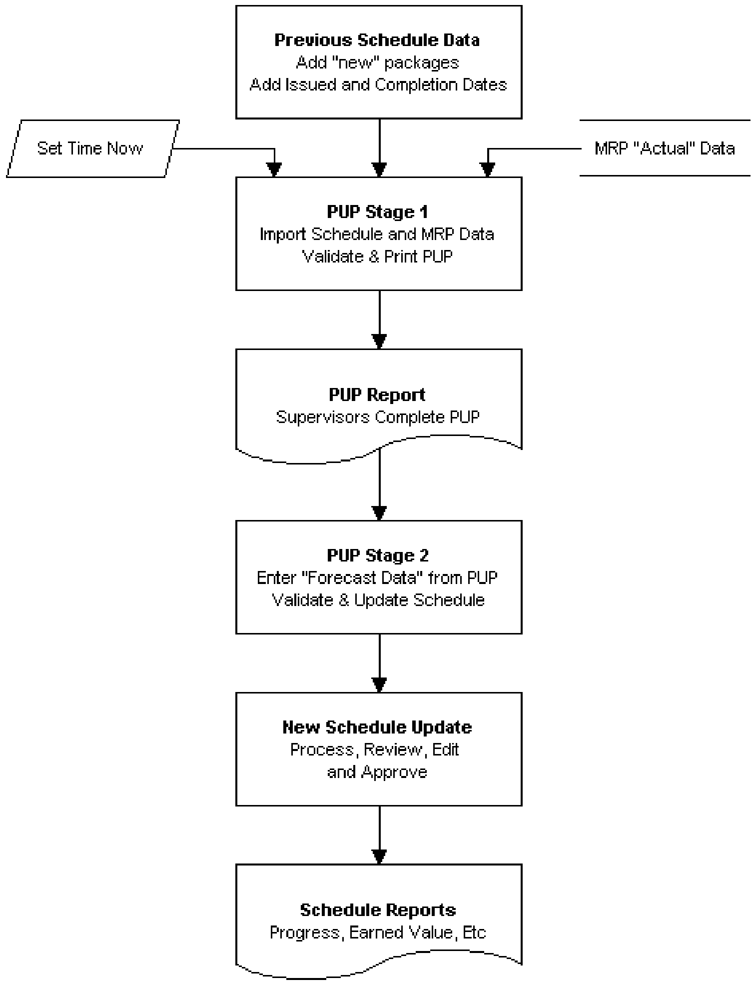
Within each package, the sequencing of individual jobs should represent the best way of tackling the work – a tradesperson should be able to open the package, start at job 1, work through to the end and know the works have been accomplished in the most effective and efficient way. If a better sequence of working is identified, the improved sequence can be locked in and stored for use in future servicings.

As packages are complete they are returned to the MCS for verification. The MCS section checks that everything is completed, signed off, and VIPER is properly updated. The paperwork is then filed and the ring binder reused. This progressive completion of verification during the servicing significantly reduces the workload at the end of a servicing.

PUP – Program Update Proforma

Managing a servicing requires a continual review of actual progress. The PUP is primarily used to gather update information for progressing the schedule, but it also provides a very effective means of communicating progress information directly to the hangar floor supervisors.

Figure 2 - PUP Process Flows



The start and end dates for each package are automatically derived from the package control processes; a package is started at the date and time it is printed. The completion date is derived from the date and time the MCS section "sign off" that the package is 100% complete, all signatures are affixed, etc. Open packages (ie printed packages that are not yet compete) require progress data to update the schedule correctly and are under the direct control of the hangar floor supervisors.

The PUP is generated in VIPER just prior to an update. Information provided to the supervisors for each package is the originally planned effort (hours), the actual effort (hours) charged to the package to date and the planned resource level allocated to the package. The information required to complete the update for each package, is in its simplest form, the effort (number of hours) expected to be required to finish the work. Blank fields are provided for the resource level to be changed (eg 2 people increased to 3) and for comments on delays, etc. to be added if the Supervisor so chooses.

Figure 3 - Typical PUP Report

The amount information requested from the supervisors is minimal and framed in terms typically used on the hangar floor, VIPER does all of the computations to divide the predicted effort to complete by the planned resource allocation to calculate the remaining duration for the package. However, the information provided to the supervisors (and tradespeople) is very powerful. If the planned effort for a task was 100 Hrs, the effort spent to date 80 Hrs and the projected effort to complete is thought to be another 60 Hrs, everyone can see immediately this package is over budget and may warrant some closer supervision or investigation of the reasons. The supervisors and tradespeople working on the package know immediately where they need to direct their attention well before the update is processed.

NUPs

Within VIPER, NUPs are a controlled document used to record and manage all unscheduled repairs (ie jobs that were not in the original set of data received prior to the commencement of the servicing) and transfer jobs between packages during the course of the servicing. NUPs are individually numbered and come in self-carbonating books. A batch of NUP forms are allocated to a servicing at the start and accounted for at the end.

When a person fills in and signs a NUP, the top copy is handed to the MCS who enter the work described on the NUP into the database. The NUP number is recorded in the database and a check number generated by the database written onto the paper NUP for traceability before the paper NUP is filed. Within the database, the NUP is allocated to an appropriate open (unprinted) package. When that package is printed, the work identified on the NUP is included with the other works ready for the tradesperson to complete. The ordering of NUPs and other work contained in the package is controlled by the MCS operators so as to present the optimum sequence of work to the hangar floor.

A similar process are used to delete jobs from one package (if for some reason they cannot be completed at that time) and allocate the job to a new package and to add additional work instructed after the servicing has commenced. VIPER checks at each start up for any unallocated NUPs and prints appropriate reports.

Systems Integration

VIPER is designed to facilitate integration with other business systems to add new capabilities, functionality and/or save costs and facilitate ease of use. The core processes addressed by VIPER are:

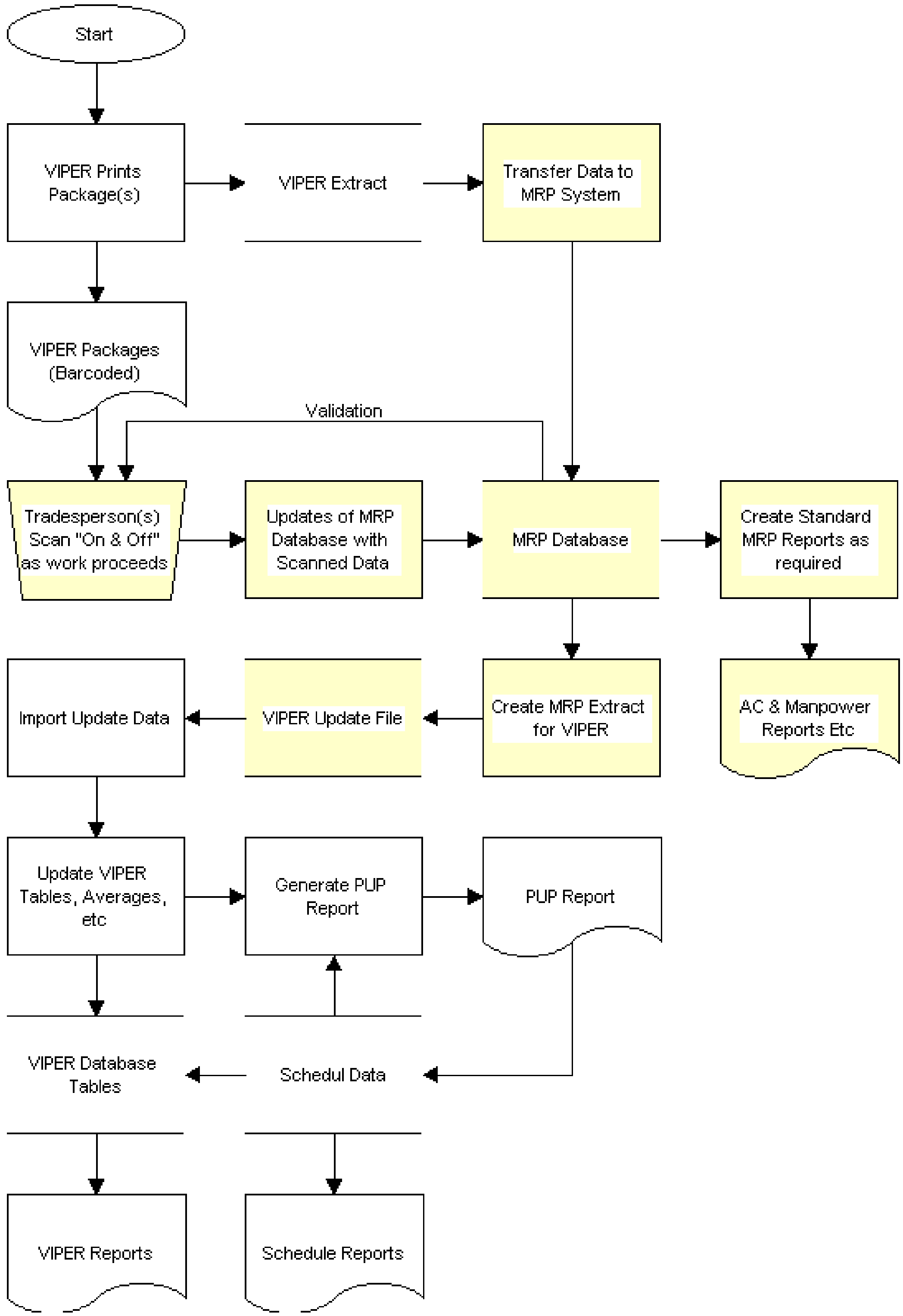
- The import and "packaging" of maintenance data.
- The creation and management of unique package numbers for each servicing.
- Prudential processes to ensure every single item of work raised against a servicing has been properly acquitted
- Close coupling of the maintenance data with scheduling processes to optimise the efficiency of the servicing process.
- Reporting on the "completeness" and schedule aspects of the servicing.

MRP, Timesheet and Accounts systems are designed (as a part of their core competencies) to deal with material costs, labour costs, progress claims, payments, etc. VIPER recognises this and does not attempt to duplicate functionality. Rather, key data are exchanged to facilitate the operations of all systems. One such flow process is described below, in this particular situation the MRP system also traps the time spent working on packages.

Links to MRP

The processes described below are specific to one particular installation. VIPER's design allows customisation of the data flows to integrate with existing installed software, current work practices and information requirements.

Figure 4 - MRP Data Flows



- The system described in the flow chart above generates a number of key data flows:
- Package information is sent to the MRP system when the package is printed (or shortly thereafter). This transfer is an intermittent batch process, driven by the user, however, checks in the MRP system prevent time and materials being charged to a non-existent codes.
- The package code number is printed as a bar code on a special page in the package to facilitate scanning. As work is done on the package, the tradesperson(s) "scan on" when they start work and "scan off" when they finish work. Any parts of consumables required for the package are also scanned against the barcode to know where they have been used.

The MRP system aggregates all of the time and cost detail for each package and each worker. It generates accounts, parts reorders, progress payment claims, etc. Facilities exist for reconciling hours booked in the wages system against the timesheet data and many other MRP focussed processes. A wide range of management reports are available from the MRP system for general use, these report formats are not duplicated in VIPER.

- Each night, the MRP system aggregates all of the times charged against each package (total hours to date) and generates an export file for down loading to VIPER.
- The actual cost data (ie hours of effort expended) are used by VIPER in the PUP report generation process (see above), Earned Value reporting process (see below) and as a basis for adjusting the current estimates for the time and effort needed to complete packages.

Earned Value – The Key Performance Indicator

VIPER's Earned Value Philosophy[7, 8, 9, 10]

Aircraft maintenance schedules generally have a few sequential tasks at the start and end joined by many dozens of short parallel paths through the "Inspection and Refit/Repair" processes. From the perspective of pure logic, there is no fundamental reason why all four engines on an Orion could not be removed simultaneously. However, resource constraints usually dictate a sequential approach to this type of work. As a consequence, the overall duration of a servicing is controlled by resource availability and the scheduled dates for many tasks by the resource levelling process.

Resource levelling at the beginning of a servicing may optimise tasks/packages in a particular sequence, (eg Engine #1, #2, #3, #4). A later analysis may optimise the sequence differently (eg Engine #1, #4, #3, #2), possibly because there is more work to complete after Engine #4 is finished (eg a fuel tank leak test). In these circumstances, comparing current schedule and baseline schedule dates on a task by task basis is not overly helpful. The servicing schedule is optimised but Engine #2 dates are substantially later than planned when the baseline schedule was stored.

VIPER addresses this issue in four different (but complementary ways):

- Overall progress is monitored against key milestones to check if the servicing is meeting the contracted Time to Make Serviceable (TMS) and other important internal checkpoints.
- Checks are implemented to note and action any packages that have been 'open' for an extended period (options exist to transfer incomplete work items to other packages if they are being delayed by external influences, eg spare parts).
- Performance on individual packages is monitored based on the hours of effort planned and expended. This means performance on the package is still relevant even if work had to stop for a week awaiting an engineering decision or a new part:

Planned effort = 100 Hrs, Actual = 80 Hrs, Forecast to complete = 15 Hrs **OK**
Planned effort = 100 Hrs, Actual = 80 Hrs, Forecast to complete = 25 Hrs **Problem**

- Overall performance (ie is adequate work being accomplished at a reasonable cost) is monitored using Earned Value techniques.

The metric used in VIPER's EV system is work hours. This metric was chosen for a number of reasons including:

- Confidentiality of financial information – For maximum benefit, VIPER's reports should be widely distributed within the workspace. Generally, financial performance data is seen as confidential, as are pay rates, charge rates, etc.
- Control and responsibility – Hangar management generally has little control over the cost of spare parts, etc. They have full control over the performance of the workforce.
- Relevance – It is possible to change workforce performance therefore measuring this component directly has the greatest impact on changing the performance of management, supervisors and workers.
- Variability (1) – The unit cost of spares and consumables is relatively static and unlikely to change during the relatively short period of a single servicing. The productivity of the workforce can change on a daily basis.
- Variability (2) – The total cost of spares consumed on a servicing can vary enormously. The cost of a new main landing strut or a new wing spar can add tens of thousands of dollars to the cost of a servicing, but management has no option other than to obtain and fit the parts. On other servicings there may be almost no new high cost components required. Adding this sort of unpredictable variable into a project control system simply devalues the overall information provided to management.

  On the other hand, the quantity of labour used on the servicing is far more predictable and controllable. The "fixed" components including preparation, teardown, inspection, refit and functional testing are "known". The "unknown" but expected repair component is estimated based on previous experience. Using these values in a project control system makes the information provided to management directly relevant to their performance.

- Easy access to data – The planned effort for a servicing (hours) is directly available from the resource plan. VIPER integrates with MRP and Timesheet systems facilitating the collection of actual hours worked. Aircraft servicing procedures require the identification of each person who has worked on a task and many maintenance contracts require the hours expended on each task/package to be recorded. Provided the data management systems facilitate its capture, all of the necessary information for generating EV reports is readily available.
- Communicability – The entire workforce is used to thinking and processing work hours. Using this common metric as the key performance measure makes the data far more relevant to everyone.

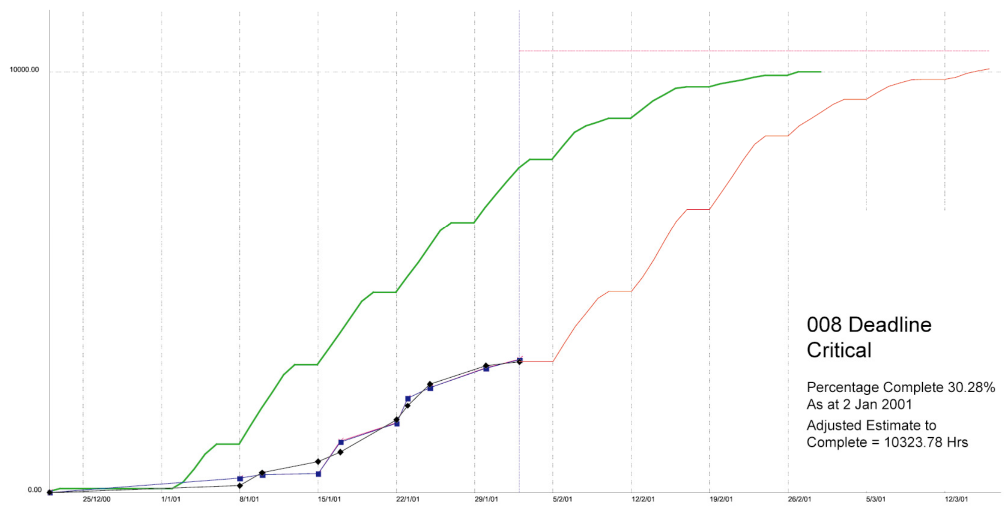
Unlike traditional Department of Defence Earned Value reporting systems, used on large acquisition projects, the VIPER system is designed to be very quick and easy to understand. Charts are produced within a few hours of the data date/time and updated once or twice a week. The focus is on providing "real time" information to all levels of management to facilitate actions to consolidate gains and mitigate losses "today".

VIPER's Earned Value Reports

VIPER uses a range of tabular and graphical reports. The primary information is the performance S-Curves. The precise layout of the report varies depending on the scheduling tool integrated into VIPER but as far as possible, the information displayed and the "meaning" of the information stays constant. The VIPER documentation, provided with each installation, is customised to reflect the scheduling tool used (ACOS, Open Plan, Primavera, Microsoft Project, etc).

Figure 5 - Typical Earned Value Chart

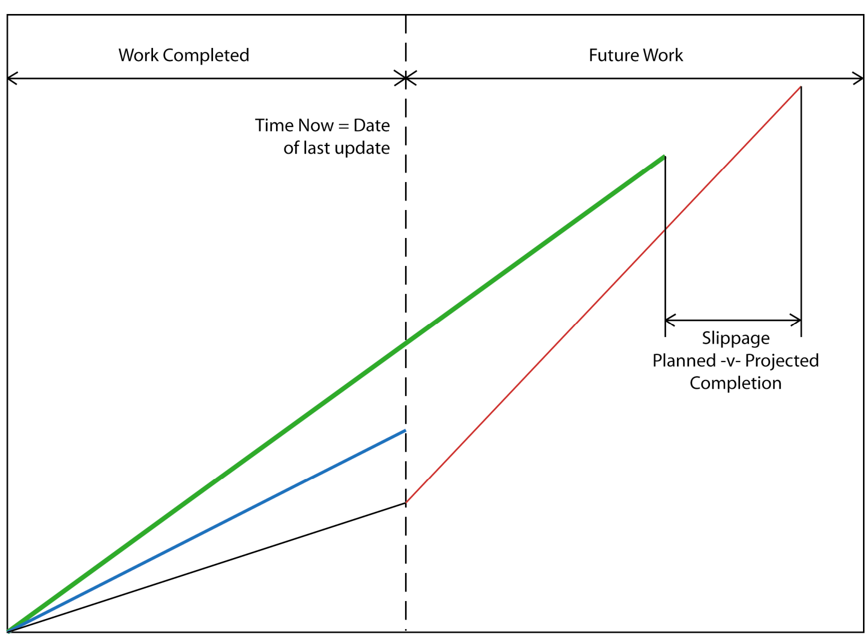
Planned -v- Actual Hours



Interpreting Earned Value Data

The "Cost Profile" report encapsulates a vast amount of data to provide management with a complete overview of the project.

Time Related Data



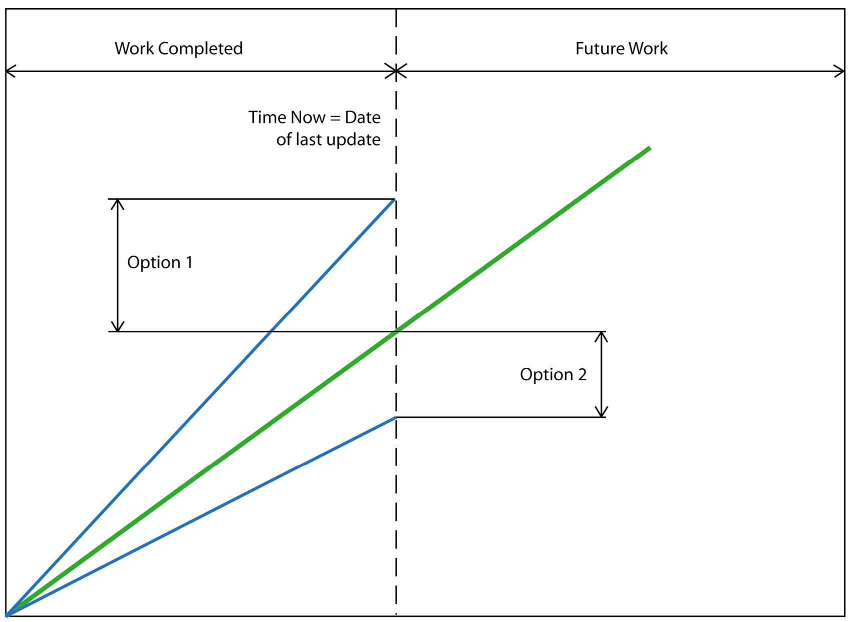
A vertical dashed line positioned at the date of the last update separates actual data input by the planners from forecast data, based on information contained in the schedule.

The thick (green) line plots the original planned expenditure of effort on the servicing from its start to its original projected end date (planned TMS)

The thin (red) line plots the current expected expenditure of effort required to complete the unfinished portion of the servicing.

The horizontal difference between the end of the thick line and the end of the thin line is the "Slippage" (gain or loss) between the current expected completion date for the servicing and the original planned date.

Budget Related Data



The thick (green) line plots the original planned expenditure of effort on the servicing. This is the original budget (measured in Man-hours) required to complete all of the work on the servicing.

The thin (blue) line plots the value of work achieved through to the last update.

The difference between these two lines (and how they are trending relative to each other) shows if an adequate **quantity** of work is being achieved on the servicing.

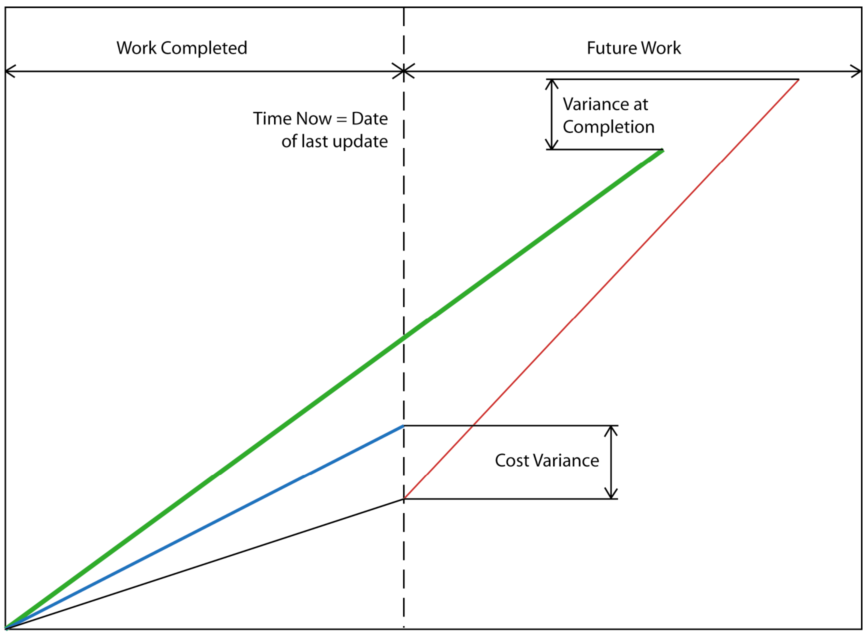
Option 1 shows a situation where the value (quantity) of work actually achieved is greater than the quantity planned to be achieved to date.

Option 2 shows a more usual situation where the value (quantity) of work achieved is less than the quantity planned to be achieved to date.

Comment

The value of work achieved (Earned Value) is based on the original plan. At the end of the servicing, the Earned Value will be 100% of the original budget; this is used to calculate the percentage complete.

Cost Related Data



The thin (black) line tracks the actual hours expended to date on the servicing, ie the Actual Cost (AC) of work performed, to achieve the work recorded as completed.

The thin (red) line projects the anticipated expenditure of effort to complete the servicing from the last update through to completion.

The difference between the black and the blue lines (Actual Cost -v- Earned Value (EV) of the work performed) shows how efficiently the work achieved to date has been performed.

The Variance at completion (ie the vertical difference between the top of the red line and the top of the green line) shows the expected over run (or under run) of costs compared to the original budget at the completion of the servicing.

Note

The value of this chart is in watching the trends develop over time. Generally a change in an established pattern is caused by an identifiable change in the project's operating environment. Similarly, to cause a desirable change in the trends, specific changes in the project need to be made. Research in the USA suggests that the Cost Performance Index (CPI) on a project will vary by less then 5% after the first 20% of a project and usually only in a negative direction.

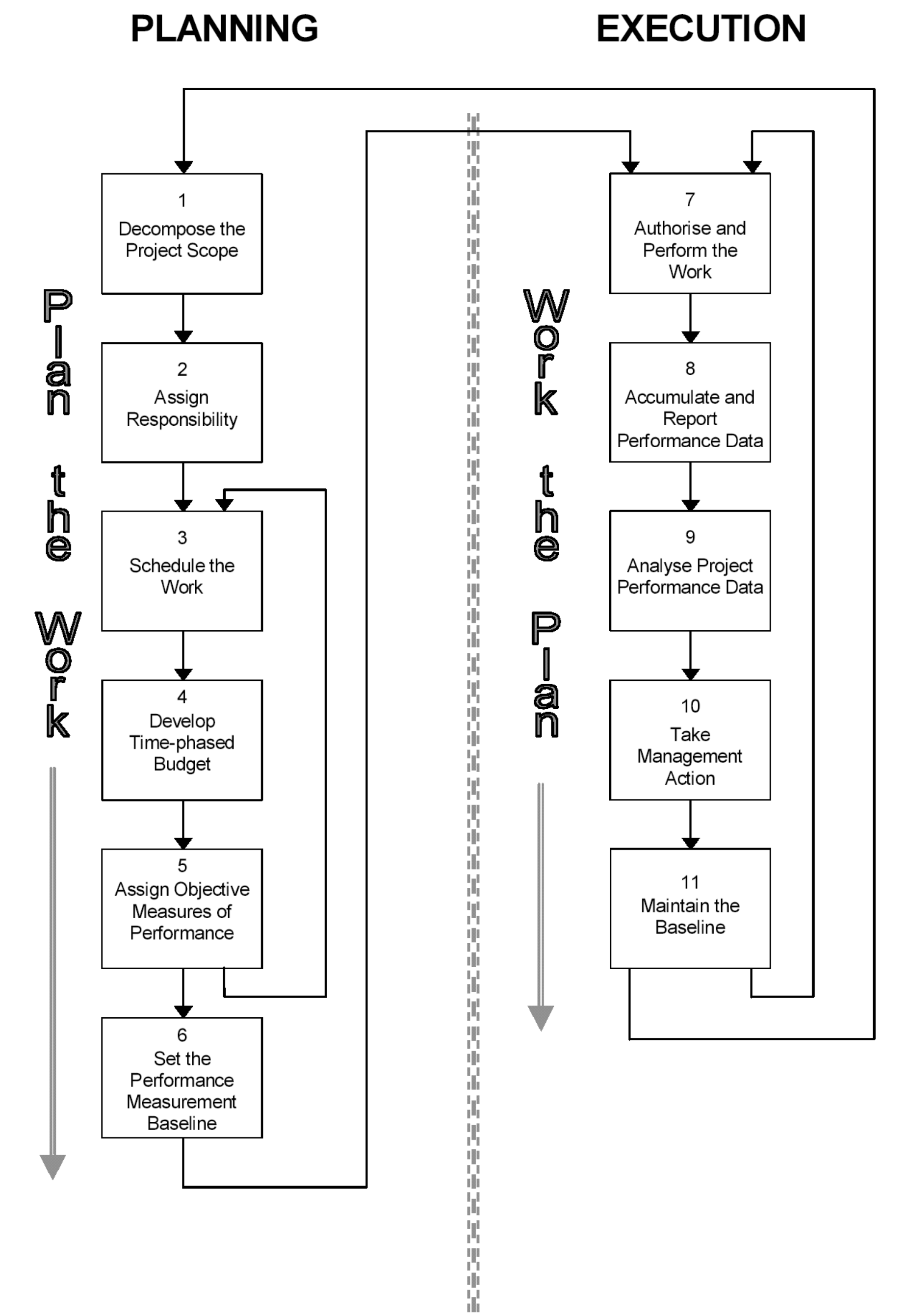
Implementing AS 4817- 2003,[7]
Project performance measurement using Earned Value.

An overview of AS 4817 - 2003

AS 4817 - 2003 was developed to facilitate the adoption of Earned Value Performance Measurement (EVPM) in the general business community. The stated objectives of the Standard are:

- To define the essential elements of the EVPM method.
- To provide enough information about how to implement the method to allow the user to gain the benefits of the method.
- To be used as a measurement tool to determine whether the EVPM method has been implemented.
- To provide a basis for EVPM implementation for all industries and sizes of projects.
- To clearly communicate the benefits of the EVPM method.
- To be fundamentally compatible with any existing Australian or International Standards.
- To be relevant to Project Managers and executive management in organisations that manage by projects.

Two of the primary references used by the committee developing AS 4817 were the PMBOK Guide 2000 Edition, © Project Management Institute and ANSI EIA-748, Industry Guidelines for Earned Value. The common thread running through these referenced standards and AS 4817 has been the move away from the prescriptive and dogmatic processes, forms and implementation check lists found in the older CSSR, C/SCSC and other "Defence" originated standards and guides to a results based approach suited to general business projects.



NOTES:

1. Steps 3, 4 and 5 are performed iteratively.
2. Not all relationships are shown.

AS 4817 - 2003, Process Flows

AS 4817 still contains a significant number of mandatory requirements, eg 'Management responsibility shall be clearly defined [for the accomplishment of each element of the work] (3.2.1b)', but how this requirement is achieved is open to the organisation implementing the Standard to determine. It is the author's view that this shift in focus from the old style prescriptive 'check lists' to AS 4817's 'normative requirements' will make the Standard easier to implement whilst at the same time creating a far more rigorous and disciplined process. Organisations no longer need to create artificial positions, reporting hierarchies and processes to obtain "ticks" in the relevant compliance boxes found in the old implementation guides. They simply need to show how their current systems comply with the requirements of the Standard. The effect of this change is to move the responsibility for the various aspects of management control and reporting from potentially artificial positions and processes (often created for the sole purpose of achieving compliance); to the organisations normal line and project management positions and processes, ie the people and processes that actually control the project. The alignment of visibility, responsibility and authority encouraged by AS 4817 should, as it is adopted and implemented by businesses, lead to far more effective project reporting and control systems.

Implementing AS 4817 - 2003 using VIPER

AS 4817 has adopted an eleven step process model (refer diagram, previous page) to describe how EVPM will be implemented in a conforming organisation. Each of these steps has a number of mandatory requirements and some supporting guidance.

When supported by appropriate management structures and processes, VIPER's Earned Value system appears to be fully compliant with the requirements of AS 4817 - 2003. A summary of each of the steps and VIPER's implementation of the process is set out below. For each 'Step', a brief summary of its requirements is included before the discussion of VIPER's support of the requirements.

1 Decompose the Project Scope

Decompose the entire project scope of work into manageable elements using a Work Breakdown Schedule (WBS).

VIPER uses a sophisticated WBS to decompose the project into elements and allow summary reporting. The capability of this process varies depending on the COTS scheduling tool specified by the VIPER operator. The ACOS version of VIPER has the following standard levels in its WBS.

- Hangar
- Aircraft Type and Model (Fleet)
- Specific Aircraft (Tail Plane Number)
- Type of Servicing
- Phase of Servicing (or alternatively Physical Location on Aircraft)

The individual work packages are allocated to the bottom elements of the WBS.

2 Assign Responsibility

Assign responsibility for the accomplishment of each element of the work at an appropriate management level.

The VIPER system requires the assignment of individual packages to the relevant supervisor. This is a more detailed level of assignment than required by the Standard occasioned by the need to achieve airworthiness requirements. Higher levels in the WBS are typically assigned to the manager responsible for the servicing but there is no system restriction to prevent other managers being assigned responsibility where appropriate.

3 Schedule the Work.

Create a schedule for all the work that identifies tasks, milestones and interdependencies. Activities are created at or below the level of work elements in the WBS. All elements of the work are to be scheduled into a logical sequence. The goal of the schedule is to provide a vehicle for evaluating actual progress (in time) against predefined objective measures of achievement. All tasks and milestones within the project should be linked with dependencies to produce a logic network that will allow the critical path, free float and total float for every task and milestone to be calculated.

VIPER fully complies with and supports this objective. The optimum schedule for each type of servicing is maintained within VIPER and translated into an aircraft specific schedule when the servicing is being set up within VIPER

4 Develop a Time-Phased Budget

Assign resources (and costs) to scheduled tasks and establish the time-phased budget. Tasks have a budget value assigned which is distributed over the activity duration and expressed in terms of dollars, labour hours, or other measurable units. Budgets should be assigned to all work elements (tasks) within a project. The time-phased budget at the detail level is defined as the Planned Value (PV). The total budget at the completion of the project is termed the Budget at Completion (BAC). The time phased representation of the total Planned Value (PV) for all tasks (or WBS elements) is the Performance Measurement Baseline (PMB). The PMB represents the formal plan for the project manager to do all of the project work in the amount of time allocated and within the amount of budget authorised to accomplish that work.

VIPER fully complies with and supports this objective. The metric used is 'Labour Hours' for the reasons discussed elsewhere in this paper.

5 Assign Objective Measures

The accomplishment of tasks is ultimately expressed in terms of Performance of their budgetary values (Earned Value). Objective measures of performance, are used to quantify the degree of completion of tasks in progress. These measure of performance should be established in such a way that they correctly measures accomplishment of in-progress tasks. The measuring of Earned Value should be computed using the same methodology as the original plan (budget). The resulting metric is referred to as the Earned Value (EV). Objective measures allows work achievement to be measured in a clear and unequivocal way. Setting the objective measures in advance enhances accountability and objectivity.

The measurement of progress used within VIPER is the estimated hours required to complete the package. This measure was selected to deal effectively with the unique problems associated with maintenance work. At any point in time, the quantity of work remaining in a package can alter suddenly, usually when an unforseen defect is discovered that requires rectification. The VIPER system always reserves adequate PV to complete the package as it is assessed at each update and as a consequence, only takes as EV any budgeted value for work that is genuinely completed.

6 Set the Performance Measurement Baseline

The Work Breakdown Structure, the Schedule, the Budget for each task and element and the time-phased budget as developed in steps 1-5 shall be approved by the Project Manager or higher authority and recorded as the Performance Measurement Baseline (PMB). This baseline provides the reference points against which actual project progress is compared, it should include the best estimates for task duration, scheduling, resource allocation, costs, and the other project variables required to be monitored. To be valid as a baseline, it should not only be logically constructed but it should also make sense when compared to available project resources.

VIPER fully complies with this requirement. Scope, cost and time baselines are stored for use in the management of each servicing. Whilst not forced by the system, obtaining management approval of the schedule before creating the PMB is normal practice for VIPER local management.

7 Perform the Work

Formally authorise all work to be undertaken and perform the work. In order for the Project Manager to exercise proper control of the project, the chain of authorisation for the commencement of work should emanate from the Project Manager either directly or indirectly. The work authorisation should clearly identify:

- What is to be done.
- Who is to do it.
- When it is to be done.
- The quantity of resources budgeted.
- Who is the person responsible for acceptance of the work.
- How progress and actual costs are to be aggregated.

These requirements are met and exceeded by VIPER and closely align with the airworthiness objectives of the VIPER system.

8 Accumulate and Report Performance Data

Record and accumulate schedule progress, earned value and actual cost for each activity on a consistent and periodic basis. Their Planned Value, Earned Value, Actual Costs, Budget at Completion and Estimate to Complete are calculated and logically summarised through the project decomposition (WBS) to properly represent the status of the individual tasks and the project in total. In addition the current schedule shall be progressed to show achievement and to provide forecast completion dates for the scheduled work.

The PUP module of VIPER fully supports this requirement.

All costs (Labour Hours) actually incurred in the performance of the tasks (AC) are accumulated at a level which will identify the cost elements and factors contributing to cost variances. The Actual Costs (AC) is compared with the Earned Value (EV) to establish the Cost Variance (CV). Earned Value (EV) is compared with the Planned Value (PV) to establish the Schedule Variance (SV).

Forecasts at completion both in terms of cost and schedule are made for comparison with current period status information and performance Reports are distributed to appropriate management levels on a consistent and periodic basis.

9 Analyse Project Performance

Identify and analyse variances from the Performance Measurement Baseline (PMB). Earned Values (EV) for tasks, elements, and totals are compared with the corresponding Planned Value (PV) to identify any variance between the amount of work accomplished and the amount of work scheduled.

The progressed (current) schedule is compared with the baseline schedule to determine slippages and forecast completion dates.

Earned Value (EV) for tasks and work elements is compared with the corresponding Actual Cost (AC) to determine the Cost Variance (CV).

Cost and schedule variances should be evaluated to determine their cause and the likely impact on the project.

Estimates of the costs at completion should be routinely developed and updated based on past trends and current knowledge and compared with the corresponding Budget At Completion (BAC) to identify the extent of the cost Variance at Completion (VAC). Forecasts of the scheduled completion should also be routinely developed and updated based on past trends and current knowledge for comparison with the planned completion dates.

These requirements are management processes supported by VIPER, recommended in the VIPER manuals and typically undertaken on a routine basis by VIPER local management. However, the performance of the analysis required by this step requires the operator to comply with the requirements of the Standard and is not 'forced' by the VIPER system.

10 Take Management Action

Take management action to compensate for past deviations or to rectify projected deviations from the Performance Measurement Baseline. The required corrective action should be determined based on the source and cause of the variance.

Corrective actions require either a change in the baseline planning or the development of a short term get well plan that is incorporated in the forecasts. In either case, revisions to planning should only be accomplished prospectively. Retroactive changes to cost, schedule or technical planning or accomplishment should not be allowed other than to correct administrative or typographical errors.

Again, these requirements are management processes supported by VIPER, recommended in the VIPER manuals and typically undertaken on a routine basis by VIPER operators. However, the undertaking of 'management action' required by this step requires the operator to comply with the requirements of the Standard and is not 'forced' by the VIPER system.

11 Baseline Maintenance

Changes to the Performance Measurement Baseline can originate either internally through the identification of unforeseen scope changes or resource requirements or where changes have been directed from other stakeholders. Where there have been changes to the project, it will be necessary to replan certain elements of the work. Due to the importance of maintaining a valid baseline for performance measurement, replanning should be accomplished:

- with proper authority;
- in a systematic and timely manner;
- should be carefully controlled; and
- adequately and visibly documented.

Replanning should not be used as an alternative to proper initial planning, nor should it be used to mask legitimate variances.

Maintenance of the Performance Measurement Baseline is required to ensure that baseline changes are properly recorded and visible and can be examined to determine their causes and potential impact on completion dates and costs. In order to maintain the integrity of the Performance Measurement Baseline the project manager should not transfer scope or budgets independently of one another.

VIPER procedures allow proper maintenance of the PMB and track and record the changes as they are made. Provided VIPER is operated in accordance with its manual, a complete history of the servicing (project) is maintained for future reference.

Conclusions, AS 4817 – 2003 using VIPER

For a VIPER system to achieve full compliance with AS 4817 - 2003, a proper combination of management processes and the built in VIPER procedures is needed. VIPER supports the prudential processes defined in AS 4817 - 2003 but software alone cannot achieve the objective and benefits offered by adopting the AS 4817 methodology.

Discussion of the 11 Steps above has by necessity been at a summary level. A detailed assessment of VIPER against each of the individual 'normative requirements' is available from Fallon Project Management Pty Ltd on request.

In conclusion, it is important to note, the more sophisticated and successful organisations using VIPER have consistently used EV reporting as one of their key business indicators for many years and consider the summary S-Chart to be the most important single piece of management information produced at each update.

Lessons Learned

Systems take time to develop

New information changes people's perceptions and expectations. A system such as VIPER generates new information and new insights that change the organisation using it. These changes then alter that organisations requirements from the system! The key "lesson" is to design flexibility into any new system and expect change.

It would have been virtually impossible to visualise, design and develop VIPER from scratch. As new functionality was developed and deployed, people could identify problems in the deployed systems and more importantly, see possibilities they had not seen before. Both of these drivers then contributed to the next round of development. The message from ASPS was that resource balanced critical path scheduling could deliver huge benefits to an organisation **but** ASPS was too complex to use – HERMES was the result.

This approach would appear to be one of the underlaying principles in the new Rapid Application Development (RAD) methodologies for software development. Deploy a simple system (or part of a system) that delivers some functionality quickly, learn from that deployment and adapt the next phase accordingly. Our observations suggest that a similar philosophy is equally appropriate in the development of a totally new system, deploying an existing complex system into a new organisation or upgrading existing systems.

Effective Information Changes Behaviour

On many occasions through the evolution of the VIPER system major improvements in performance and changes in workplace culture have occurred. These quantum improvements have almost always been associated with improvements in the quality, accuracy and (most importantly) understandability and accessibility of the information available to the general workforce.

Our observations would suggest that as the general workforce came to appreciate the meaning of the "improved" information (provided it was seen to be accurate, fair and reasonable) they changed the way they worked to achieve a "good" outcome. In many cases these improvements were spectacular; servicing durations reduced by between 30% and 50%, overtime reduced by 90%, etc. Management played a vital part in facilitating these improvements but often the results delivered by an informed and empowered workforce far exceeded their management's expectations. Another interesting factor was that apart from reductions in overtime there were no direct benefits to the workforce as a result of these improvements other than knowing they were doing their job well (and their performance was visible to their colleagues).

The key factor driving these changes was the creation of a sense of "ownership" by the general workforce (not just the planners and managers) of the information produced by VIPER and its predecessors. This was achieved by:

- Involving the general workforce directly in setting the initial targets (durations, planned effort, etc) incorporated in the "new" information. Time was allowed for discussions, workshops, etc.
- Building in a variety of processes to allow changes to the initial estimates based on actual experience. Individuals felt they could make a difference and be involved in creating improvements.
- The same information was used to set "targets" for individual jobs and manage the overall servicing. Individual performances were seen to matter.
- The data used was open, visible and accountable.

Single Source Data Ownership is Vital

Everyone is familiar with the maxim "enter data once, use many times", however, in prudential systems there is a more important consideration. Data must be owned and edited in one place only; all other users of that data must look to the "owning" source for updates and changes. This is not to say edits cannot be made in more than one place, when COTS software (particularly scheduling tools) are used in a system such as VIPER it is almost impossible to prevent changes. However, any changes made to key data in the current schedule, should be seen as temporary "what-if" changes not alterations to the core data.

VIPER achieves this objective by holding all of its key data within a database structure and down loading a fresh set of information to the scheduling tool as required. Current developments are using ODBC links to make the data more easily available to the scheduling tools.

Similarly, VIPER recognises that actual hours are "owned" by the businesses MRP/timesheet systems. Total actual hours to date for each package are down loaded on a regular basis and the VIPER database accepts the information "as is". If reconciliation is required between paid hours and booked hours, it has to be done in the MRP/timesheet system (not VIPER) and VIPER will pick up the changes at the next download.

If data have to be changed in two places, there will inevitably be times when only one change happens and inconsistencies will rapidly build up!

Measure What You Can Manage

Again, everyone is familiar with the maxim "you can only manage what you can measure", however, whilst this is true, it can also be very unfair. Hangar management have virtually no control over the cost of spare parts needed to repair an aircraft

- Prices are set by single source suppliers and/or contract negotiations.
- There is no option as to what should be replaced; in fact penalising management for overspending on needed replacement parts is counterproductive when safety and quality issues are taken into account.
- The condition of an aircraft coming into a servicing is uncontrollable.

VIPER has adjusted the maxim to "only measure what you can manage". As costs are a variable generally beyond the control of the hangar management team, VIPER measures the overall servicing duration and the effort (work hours) planned and achieved.

Most maintenance contracts have a committed time to return aircraft to service (TMS) this can be managed by adjusting resource levels committed to each servicing.

When problems are encountered, the delays need to be recorded (using VIPER's delay management processes), reports generated and where appropriate, the contract's excusable delay provisions should be actively used by management to extend the duration of the servicing. Both of these factors are directly in the control of hangar floor management and relate directly to performance against TMS.

Similarly, the planned and actual hours allowed for each servicing are directly controllable by hangar floor management. VIPER recognises that the "repair" component of a servicing can vary and separates this element for the "fixed" components (eg inspections) that are (or should be) the same on each aircraft. It is for these reasons the Earned Value system used within VIPER focuses on 'work hours' as is primary metric for measuring performance.

Automate Data Capture Whenever Possible

Whenever possible, data should be generated as a part of a "must do" process and automatically captured.

By way of example, work cannot be undertaken unless a package has been physically printed. The process of printing a package automatically generates a schedule start date for that package/task in VIPER that is part of the data used at the next update.

However, work may not start on the package immediately, VIPER therefore checks the earliest date/time hours are actually booked against the package in the MRP system and modifies the start date used by the scheduling processes as soon as more accurate data becomes available. The barcode on the package is unique, therefore time cannot be charged until after the package has been printed.

An accurate start date is essential for the schedule update process but no one has to enter the information. VIPER's automatic data capture processes ensure workload is reduced and accuracy increased.

Useability is Vital

The design of the user interface is central to achieving the often-contradictory objectives of:

- Ease of use – both new and experienced users must find the system easy to use.
- Obvious to use – the required workflow must be obvious from the screen layout.
- Incorporate all necessary prudential checks but be quick and responsive.
- Protect core data from inexperienced users and "accidents".
- Automate as many "standard" processes as possible (single button operation).
- Allow experienced users to drive and adapt the system to achieve additional benefit.

VIPER has evolved over many years into a system that balances many of the above objectives and continues to evolve in response to user requirements. A key strategy in this process has been VIPER's modular design that allows different clients to access different functionality based on their needs and the surrounding software and data systems at different sites.

Optimising the Overall System Needs Careful Balancing

An "optimum" system is difficult to achieve. All of the basic system operations (particularly those related to safety) need to be "dumbed down" and user proofed as far as possible. But skilled users still need to be able to access the powerful parts of the system to improve processes and deliverables, or fix problems and issues.

A typical example is the "locking" of packages once they are printed. Airworthiness considerations (and common sense) dictate that adding a new job to a package after it has been printed and issued to the hangar workforce is futile. The tradespeople are working from the physical document in their hand and the package itself is a controlled entity (eg all pages are numbered page 1 of 15, Page 2 of 15..… Page 15 of 15, etc.). Normal VIPER operations automatically set the printed date as soon as the package has been printed which "locks" the package. This date cannot be changed or deleted by normal system users and no additional work can be added to a "locked" package.

Notwithstanding the above, provision needs to be made for exceptional circumstances. There are provisions within VIPER for a specially trained systems administrator, using a special password to get into VIPER at a deep level and "unprint" a package by resetting the printed date. This allows the contents of a package to be changed and the modified package re-printed later. There are obvious management issues to be considered such as removing the original package from circulation, etc. The assumption built into VIPER is that if a skilled use knows how to unprint a package and is prepared to do the work necessary to achieve this, they will also know why they are doing it and what else needs to be done. Normal users do not have access to this option.

Optimise the use of Software Functionality

Optimising the overall software system for maximum effectiveness means compromising the ultimate capabilities of its component parts. Efficient systems only use the features and capabilities of each component that add real value to the overall performance of the complete system.

By way of example, the design intention of VIPER is to provide management with effective schedule data, quickly and efficiently. The system therefore only routinely uses the parts of its scheduling tools functionality that meet this objective.

The other functionality is still available to power users if they choose to make use of it but normal VIPER operatives do not need to become experts in every facet of the scheduling tool.

Understanding Data Synchronicity and Timing is Vital

Data have different time based characteristics and needs managing accordingly. Some data should not change during a servicing, some data should only change when a complete set of data is changed at the one time, and other data should change immediately an action is accomplished. Integrated data management systems such as VIPER need to identify and deal with all of these elements correctly. Examples of the different sorts of data are: -

- The base servicing data – This set of instructions should not alter once a servicing has started. If an updated data set is received it needs to be quarantined from servicings in progress and used to create the next (new) servicing.
- Schedule update data – This process requires data sourced from several different locations to be analysed "as at" a nominated date/time. Data includes "actual" information from the MRP/timesheet system (processed as a batch function), progress information from the hangar floor, package issue and return dates from the database, etc. Changes to any one set of data need to be stored until all of the information is ready for processing with a common data date.
- Package "printed" dates – This date needs to be set immediately the package is printed. As soon as a package is printed, it is locked preventing the addition of any other work to that package. The importance of this is obvious given the actual

servicing work is undertaken based on the printed instructions contained in the "hard copy" of the package. However, this date should not impact on the scheduling data until all of the required information is available.

- Storage and "clutching" mechanisms are essential. Some batch processes run at set times (eg MRP data is down loaded over night), this data needs storing until other information (eg PUP data) is available. "Clutching" mechanisms disconnect a process from the main system, eg allowing a series of "what if" scenarios to be played out in the scheduling tool without changing the main data set, and then only allowing the main data set to be updated with the selected option.
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Avoid Micro Management

The process of servicing an aircraft requires literally thousands of data elements to be identified, processed, signed off, recorded and archived. However, this is not the information needed to manage a servicing. A system like VIPER (a combination of people and software) will deal with 90%+ of the individual elements as a matter of routine. Effective management lets the system deal with the detail and focuses on:

- Progress and trends (ie who's doing what, not what is everyone doing in finite detail).
- Identification of anomalies and errors/problems (ie things that need actioning).
- Audit trails to "prove" all of the routine items have been properly dealt with.
- The ability to "drill down" into the detail when required – but not as a matter of routine.

Conclusions

VIPER and its predecessor system have delivered significant measurable benefits to both management and workers engaged in the maintenance of ADF air assets. However, the 'lessons learned', processes and concepts discussed in this paper have a far wider application than the rather specialised area of aircraft maintenance management.

Provided organisations are prepared to invest the time and resources to build effective integrated data processing systems and make schedule control an integral part of the process, similar benefits can be expected in a wide range of situations where the effective use of skilled resources to deliver complex outcomes is required.

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