Session 3
Paper (b)

Increasing Performance with Dynamic Fleet Management Systems

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1. What is a dynamic fleet management system?

Vehicle fleet controllers and their radio operators are continually required to make decisions on vehicle deployment. The speed and facility with which modern communications can offer transport tasks to a fleet owner means that more and more, the operator has to make these decisions in a shorter time. For example, the operators controlling a 300 plus vehicle fleet doing courier work in Sydney are making allocation choices on average once every six seconds, with much higher peak rates. Not only are the choices being made, but the tasks must be presented at the same rate to the drivers in the vehicles. Clearly, the decisions made at this point in the handling of the task and the technology to support them are both critical.

The essential features of a dynamic fleet management system are:-

- an effective order entry sub-system
- an intelligent task allocation sub-system
- a base-vehicle two-way communication sub-system

With such a system the operator can make more decisions with more speed, and so generate higher fleet productivity. How can a dynamic fleet management system help?

A good dynamic fleet management system can:-

- remember all of the more mundane items of data about the tasks and the vehicles
- present task data in a form easily assimilated by the operator.
- facilitate the unambiguous transfer to the driver of only that data necessary for the task.
- accept messages back from the driver relating to the execution of the task

And most importantly,

- an intelligent dynamic fleet management system can track each job and prompt the operator with recommended choices of vehicles to which the work should be given for maximum efficiency.

A dynamic fleet management system can be deployed either as pre-planning tool or to handle entirely ad hoc work. In reality, there is usually an element of pre-planning and of real time in most systems. Operators of courier fleets might have a largely real time requirement, whereas for operators of fleets of large vehicles such as tankers, the work can be substantially pre-planned.

In each case the fundamental problem is the same. It presents as the multiple vehicles, multiple tasks with time windows problem familiar to the operations research community. An intelligent dynamic fleet management system must be able to solve this problem as it applies to the particular transport operation. This solution is the core of a dynamic fleet management system, whether it is applied to the line haul operator or to the fleet around town. Around this core is wrapped an industry specific shell which embodies the rules and criteria which govern businesses in that industry. Around that shell again is built an outer shell which relates to a specific client, with values given to the rules and criteria, and often with a client-specific user interface.

It has been our experience that each client, even in the same industry, has significant differences in their requirements. While it may be more expensive to create bespoke systems, at DTM we have pursued this philosophy, and have created systems which meet the expectations of our clients. Starting with considerable experience in software, electronics and transport, we have teamed with our clients and built a wealth of knowledge covering what can be done with information technology in the commercial transport sector.

In this paper, we address the characteristics of a dynamic fleet management system, which apply to either the pre-planning or real time requirements. The reader with specific interests will no doubt identify those features which relate to his or her business.

2. The Technology Required

Provided that the appropriate intelligence is built into the system and accurate data is captured to support it, a good dynamic fleet management system can bring many tangible benefits. This section of the paper discusses the technology itself and data capture.

Job Data

In order to define each job or task to the dynamic fleet management system, the order entry system needs to capture the origin, destination, "size" and time limits for execution. These factors will usually be entered into a database. The sophistication of the database will depend on the size and nature of the business, but it will usually hold records for at least the regular customers of the transport company, so that orders can be validated. This holds true for a range of businesses as diverse as a limousine service or concrete delivery.

"Size" will be defined in different terms for different businesses, of course, and capture of this data is sometimes difficult if a customer is vague on dimensions. The origin and destination must be defined by names of locations which the system map can understand, ie by post code or suburb name. The task database must also have room to record details about the progress and execution of the task, such as the vehicle which carried the item, its driver, the times of pick-up and delivery and any other relevant details necessary to trace its execution. It is from this database also that customers are invoiced and drivers are paid, and therefore it needs to be robust and extendable.

Vehicle and Driver Data

Data relating to the vehicle, its driver or a combination of both must also be accessible to the dynamic fleet management system. Such items as vehicle carrying capacity, whether it can access particular sites, what it carries in the way of fittings such as a tailgate lift, and the skills of its driver if it is providing a service dependent on them, are all important to the work allocation decision. All of this data is relatively stable and easy to acquire, if a little time consuming. For convenience, it can also be stored in the master database used for order entry, provided it is accessible to the work allocation sub-system.

Map Data

Clearly any intelligent system required to make work allocation decisions needs to be able to trace the vehicle missions into the future. For this purpose a form of digital map is essential. The form is normally known as a node-link map, ie it is a network of roads or a representation of them joining points of interest. This type of map may be a full digital street map with every street corner a node, or nodes may be towns linked by the roads between them. This density of detail is often referred to as the granularity in a map. The art in creating a system suitable for any given operation is to build a map which is accurate and just complex enough to handle the task, but not so complex as to be demanding in its maintenance or to penalise the computing time necessary to solve any particular problem.

While there are no easy rules of thumb on this topic, it is clear that if one had only two vehicles to control in a city the size of Sydney, one would not need a highly sophisticated digital street map on which to base work allocation decisions. Conversely, if one was planning work for garbage collection over a small area with a multiple vehicle fleet, a street map could be essential.

We have found that for most scheduling decisions for say 300 vehicles operating in a large urban area the size of Sydney, a map with 1000 nodes is adequate. These would be denser nearer the central business district, and would always have a name assigned. They can be landmarks such as the harbour bridge, or client-specific depots, or just the nominal centre of a suburb.

At this point I would like to insert a word of warning. There are a number of packages on the market which claim to produce optimal schedules. They are often based on geographic information systems (GIS) with street corner granularity. They are very good at route finding provided that the map data is complete and up-to-date, but they are not good at solving scheduling problems with many dimensions. Examples of the latter might be "how many trucks should I have available for this task?" or "which depot(s) should this task be serviced from?"

GIS based route finding systems may also be comparatively slow for real time applications, where a quick despatch decision is needed. This can always be supplemented later with routing information which a GIS can provide.

Work Allocation

In order to use the above data effectively, one requires software which is capable of accepting the tasks and the resources to fulfil them, and to produce an answer to the question:- "What is the minimum cost of carrying out this work?"

As well as algorithms to compute the minimum cost across a whole fleet, this requires each cost item to be identified and given a value, or a variable function from which to compute a value depending on conditions.

To give an example:- In the transport business plan, it is stated that it is unacceptable to be late to pick-up a job. Therefore one ascribes a very high cost penalty to any violation of the stated time window, and it may well be that no vehicle is then capable of doing this particular job. In this case an extra vehicle may be drawn perhaps from a significant distance at considerable expense. If the cost penalty had been graduated so that it slowly increased with lateness, a more effective answer with a minor violation of the time window could probably have been found. In practice this is usually what happens, and the customer advised that the job will be so many minutes late. Thus the way in which human practice is replicated by the computer needs to be carefully assessed before designing the optimisation functions. In general, our software gives a penalty to all of those things which one does not want to happen. As a result, a solution is always found, and it may be one in which violations of criteria are inevitable, and which are then highlighted. At least these are then known in advance, and if necessary additional resources can be organised.

A system should always be capable of providing an answer to the deployment of a given set of resources against a task set. Or alternatively, it must tell the user the resources which are superfluous.

3. Organisational Needs

New technology such as that described above takes away some of the previous functions and enhances the human performance in handling the complex issues of scheduling and despatch. Its introduction will be much more straightforward if there is a product champion in the company. In the larger companies it is common for there to be a computer literate person who can act as system manager.

One of the first activities necessary for a successful project is agreeing on a system specification. The detail necessary can be varied according to complexity, but it is important to create expectations which can be realised. This is often fairly time consuming but worthwhile. It is during this time that an understanding of the technology and opportunities it presents can be developed. While conferences such as this one can generate a general overview of what is possible, the specification writing exercise is critical to the client understanding what he is getting into.

There are at least two other major organisational factors which impact on the success of a project. Firstly, the company must have a 100% commitment to making the system work, from the senior management to the drivers and radio operators. Secondly, and certainly in the larger projects where there may be more than one supplier, it is highly desirable that there is one authority, a system integrator, responsible for the whole implementation.

Lastly, organisationally, I cannot emphasise strongly enough the need to bring the operators and drivers into the picture from early in the project. Providing driver training in the use of the hardware, and in understanding the role of the software will overcome potential misunderstandings. Driver and operator cooperation will make the system work well, while it is important to emphasise that any dynamic fleet management system must be built so as to combine the creative skills of the human with the calculating power of the computer to produce a solution which both managers and staff "own".

4. How can a dynamic fleet management system enhance operations?

Having installed a dynamic fleet management system, how then is it likely to improve the transport service and hopefully pay for itself? One might expect some or all of the following benefits.

- A given transport task may be executed with fewer vehicles, fewer kilometres, or both. It should be emphasised again that realistic time windows for each task should be agreed, as they have a critical influence on the design of a schedule.
- The existing fleet may be able to handle more work. Naturally, this depends on that work being available, but most ambitious companies will be aiming in this direction.
- The scheduler/despatcher workforce becomes more skilled at looking at the overall picture, and less stressed by the demands of radio communication, memorising allocations and checking on work done. Furthermore, the same fleet can be organised and controlled by significantly fewer people.
- There will be more accuracy and consistency in matching jobs to vehicles. Provided that the size and nature of orders is better defined by customers, a better match of skills and vehicle attributes will result.
- Timing of jobs will be more predictable, leading to improved customer service. Customer feedback can be given on the progress of jobs as the status of all live jobs is instantly available with task tracking.

5. Analysing the System Effectiveness

It is not always easy to analyse the impact of a new system on business effectiveness. Firstly, there are often only a few grossed-up statistics on the old operation. In addition, the market environment will have changed, and the work flow will be different, as well as the usual seasonal variations in demand. Thus any comparisons should be carefully tested for before/after consistency of those external parameters over which the transport provider has relatively little influence.

Furthermore, unless the experienced transport operator has a positive feeling about the impact of the system on his business, it will be difficult to justify its performance.

There are, in each industry, key indicators such as "jobs/day/driver" or "jobs accurately despatched" which can be used. It should also be possible to monitor drivers' performance in relation to jobs delivered on time, or their acceptance of jobs offered (ie were they in the place the system had them positioned at the time of accepting a job?). Driver pay and its variability over the whole fleet is also a good indicator of the impact of the system.

In the milk transport industry there are two examples which spring to mind.

Milk is being hauled from large suppliers in the NE USA by a dairy cooperative which is rewarded for the quality of milk delivered. The receiving plants offer a price which can vary daily or weekly, and the quality of milk which they require varies. The dynamic fleet management system has to balance the transport costs against the value obtained for the milk. The system can compute the total transport costs, given the unit costs, and balance these against the possibly increased value of the milk if taken to a further distant plant. At the same time, it is minimising overall transport costs. In the operation in question, typical savings of some $6,000 per week have been measured.

In New Zealand a large dairy cooperative collects at peak 4.5 million litres of milk per day with some 35 tankers, from 1350 farms delivering to 5 different factories, each with specified production demands. Already an improvement of 5%, as measured by kgs milkfat per km, worth more than $1 million per year has been achieved. Other benefits include identification of real time problems once the schedule has gone into practice.

These two examples contain hidden benefits in scheduler stress reduction and service delivery, which are more difficult to quantify.

The simple measures of benefit with which I am familiar suggest that both the driver and despatcher productivity have increased substantially. In addition, customer service has improved and the benefits of each of these features can certainly be used in the company marketing program.

In this presentation, I have not given any cost data for a dynamic fleet management system, which is usually very client specific. Suffice it to say that the installations referred to above had paybacks measured in weeks. However, one can expect to pay at least $100,000 as the entry price for a software licence for an intelligent allocation sub-system, to which must be added the cost of the order entry sub-system and the in-vehicle and base hardware. To avoid the relatively high capital expenditure of these systems, they can usually be obtained through a subscription or rental arrangement.