Fielding The Automated Container Offering System -  
An Interim Report

by

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ABSTRACT

The Automated Container Offering System (TACOS) is a cargo booking assistant currently being fielded in the International Traffic Directorate of the Military Traffic Management Command (MTMC). The expert system automates the selection process for type and size of SEAVAN containers, ports, carrier, and ship for containerized military cargo moving from the continental U.S. to Europe. It is designed to perform all processing on simple cases and provide assistance to the human booker on complex cases. MTMC processes requests for ~1,000 containers per week on these routes. This paper is a case history which describes factors guiding development of TACOS to illustrate several themes which may occur in other (military) logistics expert system projects.

I. INTRODUCTION AND BACKGROUND

TACOS is a hybrid expert system which uses both object oriented and rule based programming techniques. It currently runs on IBM compatible 80386 based personal computers with at least 10 Mbytes of RAM. It is programmed in the hybrid shell Goldworks II and Common Lisp. Currently TACOS is undergoing field testing as communications links are completed. The system should be on-line next month (April, 1990).

TACOS is designed to automate the containerized cargo booking decision process and associated administrative tasks. This process starts with a military organization's request for cargo shipment and ends with the transmission of a

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booking offer to a commercial carrier. TACOS receives the same request information and prepares offers in the same format as the human bookers. The procedure is founded on several government regulations and semi-annual rate agreements between the military and U.S. flagged commercial carriers.

The booking process involves several steps. First the request is screened for consistency and completeness. Next the cargo type, size, and number of containers are determined. The shipper and consignee codes are used to determine the cargo origin and destination, including whether they are locations covered by the rate agreements. Candidate ports, ocean routes, and carriers are determined and the costs associated with each combination developed. Based on the cargo's date available, required delivery date, and island transit times, a sailing window is found. Next, ship schedules are used to identify the lowest cost routing meeting the sailing window. Finally, a booking offer consisting of a number of codes describing the cargo, ports, ship, number and size of containers, booking terms, etc. is prepared for transmission to the selected carrier.

By summarizing the phases of this project we show how motivations and other issues affected the project's management, schedule, and system features. We hope this discussion about "invisible guiding factors" will be a case in point for program managers, contract administrators, system developers, and others involved in military logistics expert system projects.

II. PROJECT INCEPTION

In late 1988, the U.S. Army Artificial Intelligence Center (USAAIC) and the International Traffic Directorate of MTMC (MTMC-IT) met to discuss potential Artificial Intelligence (AI) applications within MTMC. These discussions concluded that an AI application in the container booking arena was worth closer examination. During an initial trip to MTMC's Eastern Area Ocean Cargo Clearance Authority (OCCA-EA) at the Military Ocean Terminal - Bayonne (MOTBY) in New Jersey a focused review confirmed the project's merit. This was followed by a Memorandum of Understanding between MTMC-IT and the USAAIC. The USAAIC would develop a proof-of-concept prototype for MTMC-IT and install it at MOTBY for evaluation. The USAAIC resource contribution would include Knowledge Engineers (KEs), software, and hardware. MTMC-IT would provide expert bookers and data files, and develop communications hooks to tie TACOS in to current OCCA-EA computer systems.

From the USAAIC perspective, TACOS was well suited as a technology demonstration. The USAAIC hoped the project would illustrate three general points2:
- Automation and information technology are inseparably linked to the Army's future warfighting capability and AI is a technology that can make this a reality.
- As resources shrink, wise and knowledgeable decisions on investment will become more critical. AI can assist in the decision process.
- As the Army budget program strives to preserve the Tech Base, Army

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2These three capabilities were highlighted as part of a presentation by the Director of the USAAIC for the Senior Officers Seminar held on 12-14 February, 1990 at West Point, NY.
AI applications initiatives will continue to serve as a bridge in applying relevant new technological advances for Army advantage.

In particular, TACOS could provide an attractive cost/benefit ratio while enhancing MTMC’s technological perspective and supporting evaluation of AI for its impact on strategic military operations. It would train personnel in an area to which the general transportation industry was already committed while helping shape the future technological direction of the ship transport industry.

MTMC viewed TACOS as a potential tool to support in-depth options analyses while also freeing the bookers from some measure of their administrative burdens. The primary intended benefit of TACOS from MTMC-IT’s viewpoint was to improve the quality of the OCCAs’ cargo routing decisions rather than its manpower efficiency. A CONUS cargo booking staff of 25 personnel (est. $1M yearly budget) would make decisions on the routing of approximately 130,000 containers annually. The annual cost of transportation arranged by the cargo bookers was approximately $500M. The value of a marginal improvement in effectiveness would greatly outweigh even substantial improvement in booking efficiency. (Shaving 0.1% from the cost of cargo routings would have the same impact as a 50% staff reduction.)

Both CONUS OCCAs (Bayonne and Oakland) were in high cost labor markets where the recruitment of staff was difficult. High personnel vacancy and turnover rates were stressing the OCCAs’ abilities to consistently select optimal routings. In the volatile transportation business “conventional wisdom” could quickly become obsolete and creative, new, or unfamiliar booking options could easily be passed over in favor of familiar solutions. Given current fiscal policies, the OCCAs would have to continue to operate both understaffed and with a high percentage of novice bookers. This environment increased the likelihood of suboptimal bookings and increased shipping expenses.

Other MTMC-IT factors included:
- Reduced learning curve of novice cargo bookers. (The knowledge engineering phase of the project was to capture the decision process of the skilled cargo Booker and enable the novice to benefit.
- Identification of inconsistencies in cargo booking policy as implemented vs. supervisor’s instructions vs. HQ instructions vs. published regulations/contracts
- Low risk. Both low cost (due to the USAAIC resource commitment) and low probability of disruption to OCCA operations (due to the modular black box design).
- Consistent application of cargo booking strategies.

III. PROOF-OF-CONCEPT PROTOTYPE DEVELOPMENT

The development of the TACOS proof-of-concept prototype started in March of 1989 and was to continue during the remainder of FY-1989. The prototype would handle a subset of containerized bookings between CONUS and Northern Europe. Approximately 1000 containers per week were booked on these routes. The prototype would be installed at MOTBY, the largest of the booking activities.
As initially conceived, the system would be limited to verifying input information and selecting a ship, route, and carrier for one 40' dry cargo container. These limited features were arrived at through discussions with the management of the booking organization at MOTBY. It was felt that correct bookings within this limited domain would demonstrate the viability of the approach. A decision to field the system would be made if it could perform correctly 95% of the time. (A section on testing appears later in this paper.) Actual use would be in a black box mode with human verification of results before they went out the door.

The development plan consisted of getting basic information from HQ MTMC, then validating that information by working with two experienced bookers working the North Europe routes. (Using two experts would cause some duplication in knowledge gathering, but would also identify inconsistencies in procedures.) The USAAIC development team consisted of two KEs, each working half time. One developed the booking logic while the other developed the interfaces and testing plan. HQ MTMC provided data bases and their perspective of the booking process. In addition to the booking section, two MOTBY support groups were involved, one under MTMC-IT, and one under MTMC Information Management (MTMC-IM). The MTMC-IT group directly supported the bookers in using and maintaining their computer terminals. They would be trained to answer simple user questions and spot development bugs. The MTMC-IM group maintained the main computers and databases. They would develop the communications and database hooks needed to tie TACOS into existing systems.

The MTMC-IM group at MOTBY would also be the ultimate maintainers of the system. However, MTMC-IM management did not want to maintain a stand-alone AI system written in languages they had no experience in. Rather, they wanted the prototyping project to produce a hardcopy report of the distilled booking knowledge. The knowledge could then be imbedded in a new systems design, making "TACOS" easier to maintain. This issue was essentially ignored during early development since we felt that a successful system would not easily be discarded, while no one would care about the logic of a failed system. Maintenance and reporting issues just seemed too far away to worry about.

The first delivery of a working prototype was achieved within two months. Updates were installed roughly every 3 weeks. This initial system was totally stand-alone. Booking input was by hand via a formatted screen. The initial output screen showed most relevant booking factors, and limited decision information was provided on auxiliary screens. Testing was slow, but the logic improved quickly. By June, we decided to start using existing MTMC databases to build a more complete world model. Since we were using object-oriented programming techniques, expansion of the system to include all carriers, multiple size and number of containers, and all routes from CONUS to Europe was easily performed. Expansion to model the rest of the world was postponed due to memory requirements.

IV. FROM PROTOTYPE TO PRODUCTION SYSTEM

During the first Interim Program Review (IPR) in early July, 1989, TACOS was demonstrated and plans for the rest of FY-1989 discussed. Even though significant logic testing had yet to occur, the progress to date, including early extension past the original scope impressed the MTMC-IT management. At this time the Director of International Traffic at MTMC asked to have the project objective
changed from a proof-of-concept to a full production system, with fielding to occur in mid-FY-1990.

System fielding was not a role that USAAIC was ready to support, since their interest was to demonstrate the technology, not to act as turnkey developers. However, the USAAIC's project manager for TACOS was actually an employee of the Idaho National Engineering Laboratory (INEL) on loan from the Department of Energy. The INEL would support fielding of one-of-a-kind systems such as TACOS on a cost recovery basis. Since the project manager would be returning to the INEL at the end of FY-1989, all parties felt that transfer of development to the INEL was advisable at that time. The final months of the USAAIC effort focused on logic testing and a smooth project transfer to Idaho. Meanwhile MTMC-IT obtained $100K of year end funds for the INEL effort.

Fielding planning revealed several new requirements. To enter a production mode TACOS would have to be hooked into the other computers which handled request queuing, ship, site, and rate databases, and the offering E-mail system. A related issue was the long term maintenance of both TACOS and the associated communications systems. Another new requirement was that TACOS perform automated screening of booking requests to determine which cases were outside its scope. This screening was being performed by hand. One final problem concerned whether TACOS should operate in a black box mode (as desired by MTMC-IT management), or as an assistant or tool for the user (as desired by the bookers and recommended by the KEs). A powerful offer review capability was needed to support black box mode confirmations. We hoped that minor extension of these capabilities would also support the "assistant" mode.

Soon after the transfer to the INEL at the start of FY-1990, increased workloads limited the availability of bookers to review TACOS capabilities. This caused user interface enhancements and logic testing to be put on the back burner. Emphasis was shifted to automated screening development and computer communications hooks - areas not requiring booker review.

By the January 1990 IPR it was apparent that the communications hooks were on the project's critical path. Scheduling problems were occurring in development and testing of ties into existing operational systems. A plan was developed where MTMC-IM would provide interim hooks by March 1st to support fielding in April. This would provide important operational data, including a better measure of the eventual payback. Then in 1991 TACOS would be ported onto a UNIX environment using X-windows, C, a database language, and some Common Lisp. This hardware/software change was in the direction of the planned new MTMC-IM system, so maintenance training and embedding would be easier. It would also increase the speed, efficiency, and capacity of TACOS, providing important "growing room" for the system. Finally, it would improve the communications capabilities between computers. Our status as of mid-March is described below after the testing section.

V. LOGIC TESTING

The first formal system logic tests were designed in July of 1989. In initial discussions, the management of the booking section at MOTBY had stated that a 95% "success rate" would be needed for full operation. If TACOS rejected a case it would not count against the program, so an initial, limited scope system would be acceptable.
The problem with this success criteria was how to measure performance. From a technical viewpoint, only bookings that had no deviations from the final human booking could be a complete success. Unfortunately, some reasons for deviation such as database errors were not the responsibility of TACOS. Also, TACOS was designed to come up with the least expensive initial booking offer, but there was no guarantee that this initial offer would be accepted by the carrier. Often carriers rejected offers due to full ships, etc., resulting in the final (accepted) offers being different. Finally, some measure of correctness other than "all or nothing" was needed. There were several factors associated with each offer which could be evaluated. However, few of the factors were independent - if TACOS was wrong on one factor, the result could cascade to several others.

In spite of these difficulties, we decided to compare the TACOS results against the final human booker results. We would review each case and place each booking factor into one of several categories:

1) Completely correct,
2) Minor technical error (e.g. minor programming bug),
3) Explainable logic error within TACOS scope,
4) Error outside scope (database, screening, etc.),
5) Part of the initial solution but not the final solution (carrier rejection of initial offer), and
6) Initially unexplainable.

Due to booking factor interdependencies, we also kept track of the number of root cause errors per case. For example, suppose that TACOS selected a particular port of embarkation over another due to linehaul rates. From that decision, a ship and route were selected. However, the bookers picked a different port due to specific information in a free format remarks section TACOS couldn’t digest. In this case the ship and possibly route index would show as booking factor errors. This would usually also produce errors in sailing and arrival dates. Thus one root cause error could produce four or more booking factor errors.

Our testing plan was to run ~100 cases once every month, compile statistics, correct simple (category 2) errors, rerun the cases, and compile new statistics. In this way we could measure system progress. An initial field test and subsequent lab retest of 37 cases was conducted in August. Despite testing limitations it was found that TACOS did very well given its early developmental stage. Very few errors were initially unexplainable, and in subsequent tests most errors quickly fell into categories 4 and 5. There were even several cases where the review group decided the TACOS selection was deemed better than that of the human booker.

VI. CURRENT STATUS

Currently, TACOS can accept unfiltered requests for bookings in a batch mode. The requests are processed one at a time. First, input verification is performed and incomplete database information and out-of-scope checks are run. Accepted cases are processed and an offer is prepared. Finally, the offer is presented to the user to accept or modify. The user interface is menu based to eliminate typing errors and TACOS uses constraints to prune out nonviable menu selections. TACOS can also run through the day’s cases uninterrupted, producing a printout
for the bookers to review before their computer session. In the uninterrupted
mode, TACOS averages 2 cases per minute.

On average, TACOS accepts ~40% of the requests for processing. The rejected
cases split evenly into commodities and destinations outside the scope of the
system. Recent logic tests on TACOS indicate a 7% error rate across all booking
factors for cases within scope, with a 2% error rate attributable directly to
TACOS logic. The logic errors are in areas where we have not fine-tuned the
expert decision process. For example, logic is not complete for mimicing human
bookers in "bending the rules" of inland transit times and required delivery
dates. On the other hand, only 1 in 2 cases processed are completely correct.
This means that TACOS gets most cases "almost right", and the booker only needs
to perform minor adjustments.

Even though fielding is a few weeks away, TACOS has been providing limited
payback for some time. During knowledge acquisition we identified several
inconsistencies in procedures and booking codes. Sometimes the inconsistency was
between published procedures and what was actually doable. Other cases involved
vague directions interpreted differently by each booker. Typically, HQ MTMC was
asked to provide resolution. Thus, the TACOS project has already played a role
in refining the booking process.

VII. FUTURE EFFORTS

The high priority item for TACOS at present is to get it integrated with day to
day operations at MOTBY. This is needed to develop additional funding support
for the effort. Next, we will be fine-tuning the logic and adding features to
the user interface as they are requested. Based on operational data, we will
determine the best extensions in scope to perform. Potential extensions are to
include refrigerated cargo and vehicles, perform reanalysis when the first offer
is rejected by the carrier, and work cost optimization problems across multiple
requests simultaneously. Weekly and monthly report generators are also under
discussion. Installation at the Western Area OCCA in Oakland is planned, but
OCONUS OCCAs and inbound bookings are not being considered yet. Finally, there
is porting of the code to hardware and software maintainable by MTMC-IM in FY-

To date, only $75K has been spent on TACOS development. However, the total
manpower effort is approaching 1 1/2 man years. Much of the equipment and
software in use is borrowed, further holding down costs. Expenditures will rise
as new equipment is procured to support the expanded fielding of the system.
Actual savings will be more easily tracked once TACOS is integrated into daily
operations.

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