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Quick-Time Review M113 Tracked Vehicle Life-Extension

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SYNOPSIS

Experience in auditing and reviewing capital projects, particularly in the land environment, has shown that evolving Force Structure frequently affects equipment requirements, in terms of numbers and distribution. In the case of the M113 Vehicle Life-Extension Project, the ultimate requirement has been sufficiently flexible to accommodate reduced vehicle numbers, in favour of quality, delivery schedule and budgetary realities. As it happens, flexibility was built into the Project mandate; the Project approval established a maximum on the vehicle quantity.

The M113 Project was developed to life extend and re-role up to 406 vehicles for use as tracked support for front-line combat tracked vehicles. The Project was approved in October 1998 at a cost of \$336M (later increased to \$366M) for the production of a number of vehicle variants such as personnel, cargo and engineering. The work was to be performed at a departmental facility, 202 Workshop Depot. A contract was signed, in January 2000, with a large engineering firm for 341 vehicle conversion kits, with an option for 61 more.

As Project definition progressed, it became apparent that the original risk assessment and costs had been under-estimated. Principally, requirements continued to evolve, and production processes were more labour-intensive than expected. By February 2002, the Project was behind schedule, and forecasts indicated that the approved budget would be exceeded. Accordingly, in May 2002, it was decided to forego the option for the additional 61 vehicles. Subsequently, in November 2002, the Department approved a revised requirement for 289 vehicles, based on an Army reassessment of need.

The new target of 289 vehicles brought the Project back in line, in terms of budget and schedule, but represented a 29 per cent reduction relative to original vehicle numbers. Had the Project continued to target delivery of the maximum/original vehicle quantities, the budget would have been exceeded by approximately \$85M. At the same time, there have been improvements in operational capability and versatility for each vehicle. Early indications are that users are also satisfied with the product.

This Project is being delivered through the matrix, managed by a small team working substantially on a part-time basis. In this context, it hasn't had the benefit of a specific project office or of sufficient oversight by a Senior Review Board.

Ultimately, the Project has been adversely affected by a lack of front-end appreciation of complexity and risk; limited project management resources and oversight; and, lack of ongoing assessments of the balance between performance, cost and schedule objectives. At this stage, there remains little margin for error, as all contingency funds have been committed. The reported recommendations are intended to better ensure the future progress of the Project.



The key management actions stemming from the recommendations are as follows: (See Annex A for more detailed text.)

- *Oversight. The Project Leader will assign oversight commensurate with that of a Major Crown Project. The Assistant Deputy Minister (Materiel) (ADM(Mat)) will receive a comprehensive quarterly Project Progress Report.*
- *Resourcing. A review of resources will be undertaken with any shortfall, and planned resolution, to be identified in the above-noted quarterly Report.*
- *Design Freeze. Requirements and design will effectively be frozen in Fall 2003.*
- *Cost/Capability Matrix. The utility and application of this tool will be reviewed.*
- *Lessons Learned. Lessons Learned will be evaluated within the calendar year, to identify those warranting capture in project management tools and training.*



CAVEAT

Note that this document reports the results of a *Quick-Time Review* conducted at the specific request of management. As such, the work does not conform to the standards and rigour as would occur for an internal audit. The reader is cautioned in this respect. At the same time, the observations and conclusions are sufficient to support the formulation of recommendations for consideration by management.



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EXECUTIVE SUMMARY

The progress and achievements of the Project have been adversely affected by: insufficient front-end planning, including appreciation of complexity and risk; acceptance of critical, yet unfounded, assumptions; limited project management resources; limited oversight; and, implementation strategies which have not profited from ongoing assessments of the balance between performance, cost and schedule objectives. Through reduction of vehicle quantities, the Project has remained within cost and schedule. There is a substantial improvement in operational capability and versatility per vehicle as well as overall user satisfaction.

The M113 Tracked Vehicle Life-Extension, having an approved budget of \$366M, was developed to address the future tracked vehicle support requirement for the Canadian Forces. The Project was introduced to life extend up to 406 M113 vehicles, in the form of nine variants. Delivery is being managed through the matrix, with production work performed at DND's 202 Workshop, in Montreal. The Project was identified as *Low Risk* and is to field the vehicles by 2006/07.

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By February 2002, the Project was experiencing difficulty relative to schedule and budget. Accordingly, in May 2002, a decision to forego the option for 61 vehicles was taken, fixing quantities at 341. Six months later, to align with the revised Army requirement, the vehicle numbers were reduced to 289. Had the Project continued to target delivery of the original vehicle quantities, the budget would have been exceeded by approximately \$85M.
At this stage, there remains little margin for error, as all contingency funds have been committed.

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The observed cost growth is largely attributable to: additional requirements approved after the budget was set (\$40M); requirements for which costs were under-estimated (\$20M); labour costs for additional employees at DND's 202 Workshop (\$10M);and, unanticipated exchange rate increase (\$15M as of November 2002). Project management did not systematically assess the cost implications of project additions/changes and did not propose potential trade-offs between cost and capability.

This Project has been managed through the matrix by a staff of seven part-time personnel; not enough, considering the complexity and budget of the Project. The limited project management complement has proven a false economy. Visibility, oversight and project management resourcing were less than would have occurred had the Project been designated as a *Major Crown*.



Project definition and implementation are being pursued concurrently. This has had implications for the clarity of the scope of work to be accomplished. Prior to obtaining Effective Project Approval (EPA), it was assumed that production costs would be similar to those for a US M113 Life-Extension. Initially, costs were developed for only two variants, as it was assumed that costs for other variants would be within the same levels. As it happens, labour hours for vehicle production have doubled over original estimates.



REVIEW APPROACH

INTRODUCTION

This Quick-Time Review of the M113 Life-Extension Project (M113 LE) was requested by the Vice Chief of the Defence Staff (VCDS) and the Chief of the Land Staff (CLS). The number of vehicles had been reduced by 29 per cent, from the approved maximum, while the funding remained constant. Notwithstanding certain capability enhancements per vehicle, the average cost per vehicle has increased significantly over the estimates – in total, this increase amounts to about \$95M.

REVIEW OBJECTIVE

The objective is to provide an independent review and analysis of circumstances affecting the budget, deliverables and associated trade-offs for the M113 Vehicle Life-Extension Project.

REVIEW SCOPE

The Review focus is on the development, definition and implementation of the M113 LE Project.

REVIEW CRITERIA

The Review used the Defence Management System and recognized project management practices as criteria. In this respect, it involved a reasonability check.



M113 PROJECT BACKGROUND

The Project:

- Developed to life extend and re-role up to 406 tracked vehicles.
- The Project was developed to meet a capability shortfall attributed to a decision to purchase 651 Light Armoured Vehicles (LAVs), against a stated requirement of approximately 1800 new-wheeled vehicles.
- Despite a move toward a predominantly wheeled fleet, life-extension of the in-use M113 tracked vehicles was viewed as cost-effective and affordable.
- Estimated per unit cost of \$900K (i.e., \$366M/406 units), compared to the average unit price of \$3M for a new LAV (\$1.9B/651).
- Industrial and employment benefits were also viewed as positive.
- The 406 vehicles included nine variants (e.g., Personnel, cargo, engineering).
- Approved in October 1998, with a budget of \$335M; later augmented to \$366M, in December 1999, to accommodate an additional requirement (a Protected Weapon Station).
- A sole-source fixed-price contract was awarded in January 2000, for engineering services.
- The actual production is taking place at 202 Workshop Depot, a DND land maintenance facility in Montreal.
- 202 Workshop Depot Labour costs were not included in the Project costs.
- The Project was identified as *Low Risk*.
- The Project is being managed through the Matrix; it was not classified as *Major Crown*.



- By February 2002, the Project was behind schedule.
- In May 2002, a decision to forego the option for 61 vehicles was taken, leaving 341 for production.
- In November 2002, the approved requirement/quantity of 341 was reduced to 289.
- The reduction from 406, to 341, to 289, aligned with funding and allowed schedule recovery.



PRINCIPAL OBSERVATIONS

CAPABILITY SHORTFALL

- The Project has had to cope with uncertainty and change, relative to requirements:
 - Changing/Evolving Army force structure and organization
 - Definition of tracked/wheeled fleet mix
- Remains unclear that current quantity of 289 vehicles represents a requirement for the future.
- Conventional wisdom is that the costs of the M113 LE amount to one-third of the cost of new Light Armoured Vehicles (Wheeled). This warrants further analysis in view of the full costs of the M113 LE, including \$45 – \$50M direct and indirect costs associated with 202 Workshop Depot.

IDENTIFYING AND ASSESSING RISKS

- The Project was given an assessment of *Low Risk*.
- Intuitively, challenges in rebuilding a 30-year-old vehicle into nine variants, including cutting and stretching the vehicle, would seem relatively formidable and this has proven to be the case.
- Contracted studies characterized the risk as *Medium-to-High*. Key risks identified included resourcing, cost/scheduling control and the impact of changing requirements.
- Impact of exchange rates identified as *Low Risk*. Actual rates were 1.59, vice 1.47 estimated. The change in rates consumed half the Project's contingency funds. Recent changes in the dollar may provide some relief.



COST ESTIMATING

- Cost estimates were largely based on US experience with two basic variants.
- Canadian life-extension program has been more complex than US.
- Over 100 of the Canadian rebuilds involve cutting the hull in half and stretching the vehicle – this was not in the US rebuild at the time.
- Labour estimates per vehicle understated at 1000 hours (actually 1500-2400 at 202 Workshop).
- Decision to develop MTVC/MTVF(cargo/crane) variant, valued at \$26M, not included in cost estimate at final project approval.
- Change in requirement for cranes mandated to this Project to ensure CF-wide standardization.



COST GROWTH**Breakdown of Current Funding Difficulties (All costs approximate)**

Additional requirements not costed, such as engineering rework for new cranes, winches, unforecasted TCCCS integration and MTVF/MTVC requirement	\$ 40M
Requirements for which costs underestimated (e.g., electrical system upgrades)	\$ 20M
Additional Labour costs for new hires at 202 Workshop	\$ 10M
Unanticipated exchange rate increase	\$ 15M
Sub-Total	\$ 85M
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Total Additional Costs	\$ 95M*

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* Assuming the Project remains at \$366M, the per unit vehicle cost will have risen from \$.9M (\$366/406) to \$1.26M (\$366/289). The differential of \$.36M per unit reflects a change in the order of \$100M relative to the vehicle quantities originally anticipated.



PROJECT CONCEPT

- EPA indicated almost all definition work completed; in fact, definition continued into implementation. During prototyping it was determined an additional chassis would be required for the Cargo and Fitter variants, with a \$26M impact on the budget.
- Changing requirements created need for additional definition during production.
- 202 Workshop has experienced difficulties with Technical Data Packages related to untried technical drawings requiring modification.
- Some fielded vehicles need minor retrofits.
- Not all variants yet in production.

CONTRACTING

- The contracting structure involved a Canadian prime and a U.S. sub-contractor, the OEM.
- Tiered structure affected timeliness of information and cost – data packages had to be obtained from the sub-contractor, through prime.
- A number of items in the contract not costed, but designated as ‘To Be Determined’. Cost impact only known as the first Contract Change Proposals were submitted in February 2002. To date, cost impact amounts to \$17M.

DESIGN AND SCOPE

- Large number of changes, including the MTVC/MTVF (cargo/crane) requirement, added after Effective Project Approval (EPA).
- Engineering Change Proposals (ECPs) submitted without cost impact. Trade-offs not systematically assessed as changes introduced, such as cost impact of new cranes and integrating TCCCS.



INDUSTRIAL PRODUCTION

- 202 Workshop did not have required personnel on hand. For example, 202 had six welders on staff, but Project required 50.
- Estimated number of hours per vehicle rose from 1000 hours to 2400, requiring additional labour. Estimated steady state is in the order of 1500-2000 hours per vehicle.
- Estimated 202 Workshop could produce 60 vehicles per year. Actual production has proven to be 36 and must be augmented through costs of \$10M for additional labour. Original schedule of completion by 2007 will be maintained, but for 117 fewer vehicles than originally planned.
- Decision to build all variants for a region rather than singular variants, while advantageous for fielding and Integrated Logistics Support requirements, complicated the production process.

OVERSIGHT

- Visibility and oversight reduced by decision to deliver the Project through the matrix.
- With costs escalating, annual Senior Review Board postponed three months, resulting in 15 months without SRB oversight.
- Issues not raised to Program Management Board until November 2002, about one year after the Project was in difficulty.
- Approval based on an upper limit for budget and vehicle quantities (34 of which were ADATS), established a questionable basis for oversight.



PROJECT MANAGEMENT

- Managed through the matrix, vice dedicated project office.
- Not classified as an MCP – less visibility, personnel and oversight.
- PM is Lieutenant-Colonel; matrix staff are part-time; engineer position unfilled; procurement (PG) position staffed for two years at two levels below requirement.
- No on-site dedicated support from outside the Department (i.e., PWGSC, IC).
- Project substantially driven by performance, schedule.
- Little ongoing analysis of cost trade-offs; project office not staffed with this capability.

SCHEDULE AND PERFORMANCE

- With reduced vehicle quantities, completion date remains on track at March 2007.
- The increased cost provides a substantial improvement in operational capability and versatility per vehicle and there is overall user satisfaction.



CONCLUSIONS

The achievements of the Project have been adversely affected by:

- Assumptions which have not been sufficiently challenged.
- Limited project management resources.
- Implementation strategies which have complicated production.
- Insufficient oversight (no Senior Review Board for 15 months, from February 2001 to May 2002, and issues not raised to Program Management Board until November 2002).

Cost and budgetary difficulties amount to \$95M relative to the vehicle quantities originally anticipated. The reduction from 406 to 289 vehicles is clearly substantial. It removed all of the ADATS requirement (34 vehicles, for which funding will have to be found elsewhere).

Other factors contributing to cost and delays:

- A tiered contract structure, such that the subcontractor, who was the original equipment manufacturer, was accessed through the Canadian prime.
- A concurrent definition and implementation process.
- Limited-to-nil economies of scale due to relatively small production quantities for most variants – compounded by fleet replacement on a regional basis i.e., production of regional variant mix).
- A small project office staffed on a part-time basis.
- Initial production being undertaken by a staff without the necessary skill sets.
- Engineering Change Proposals not systematically evaluated for cost/capability implications.



RECOMMENDATIONS

We are not convinced that measures are in place to ensure that difficulties will be monitored and overcome. Accordingly, we recommend the following action by ADM(Mat), in consultation with Chief of the Land Staff (CLS), as necessary:

- Initiate oversight commensurate with that afforded a Major Crown Project.
- Ensure that the project office is fully/appropriately resourced.
- Freeze remaining designs and requirements, at the earliest opportunity.
- Create a cost/capability matrix to evaluate engineering change proposals, as they arise.
- Obtain costs on outstanding *TBD* contractual items.



LESSONS LEARNED

- Limited project management resources have proven a false economy.
- Use of DND in-house production facilities, should be recognized as project costs.
- Accelerating a project requires additional/concentrated attention and oversight. Omission of steps, or performing important steps concurrently (i.e., commencing implementation, prior to definition), increases risk – this must be recognized, acknowledged and managed.
- Requirements and design must be frozen, and changes limited, or at least fully evaluated, at the earliest stage possible.
- A cost/capability trade-off matrix is an essential management tool to effectively assess and deal with change proposals.
- Without a thorough risk analysis, risks tend to be understated and, ultimately, actual risks become compounded. This project should have been identified as *high-to-medium risk*. An inventory of factors which tend to increase, or moderate project risk, should be provided as guidance to project managers.
- Assumptions need to be explicitly stated and challenged at the time of project approval. Uncertainty should be addressed as part of the risk analysis.
- A firm fixed-price contracting strategy can be undermined by an inordinate number of costs which remain *TBD*.
- Tiered contracting structures, particularly involving non-Canadian sources, can add to schedule and costs.
- Large, complex, matrix-managed projects, not designated as an *MCP*, may not trigger sufficient oversight.
- Options analyses should be based on life-cycle costs.



ANNEX A – MANAGEMENT RESPONSE

Project Oversight. DGLEPM, as Project Leader, will assign oversight commensurate with that of a Major Crown Project. This will include providing ADM(Mat) with a quarterly Project Progress Report. Areas to be monitored are:

1. Current Project Status: Costs and Schedule.
2. Status and Target Dates for Finalization of: Additional Work Required (AWR); To Be Determined (TBD); and Contract Change Proposals (CCP), as related to Cost and Schedule.
3. Current 202 Workshop throughput, with projections on Schedule.
4. Details of existing or potential problem areas that could impact Cost and Schedule, both contractually and with 202 Workshop.
5. Current Critical Path items.
6. Status and Target Date for completing Definition work.
7. Contingency Assessment.

Project Resourcing. The project ENG 04 position has been staffed. A review of Project Office and 202 Workshop resources will be undertaken to determine if additional personnel are required. Should additional resources be required, the report will address how the shortfall will be met.

Design Freeze. It is intended to complete the Repair Team, Recovery, Cargo and Fitter variant designs in the Fall of 2003, effectively freezing the final requirements and design.

Cost Capability Matrix. The Project Manager will review the utility of using a Cost/Capability Matrix and consider its application in project management and decision-making.

Lessons Learned. Lessons Learned will be examined this calendar year to determine which are the best examples to reside on the MA&S Desktop and be incorporated, where appropriate, into Project Management Courses.

