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RISK CONSULTING DIVISION

3 February, 2009

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Subject: ***Explosives Safety Siting Consulting***
Review of Potential Explosion Risk Study
for Suburban Rail Line Extension Report

Dear Sir:

This letter summarizes the results of our review of the Potential Explosion Risk Study for Suburban Rail Line Extension Report prepared for the Agence Metropolitaine de Transport (AMT)[1].

1. Background

General Dynamics (GD) operates a site with explosive storage magazines (ESMs) used in the process of manufacturing ammunition. According to GD, the storage magazines are currently sited properly in accordance with NRCAN regulations and quantity-distance (Q-D) criteria.[2] However, a passenger commuter rail line has been proposed that crosses into the required Q-D explosive safety arcs. There are sixteen explosives and ammunition storage magazines of varying construction and a Safe Marshalling Area (SMA) where explosives laden semi-trailers are parked. Construction of the rail line would create non compliance with NRCAN Q-D requirements and would restrict explosives storage at the site.

The AMT commissioned a risk analysis for the encumbered rail line to determine whether risks posed by the rail line encumbering the required Q-D separation were acceptable. The risk analysis results are summarized in the AMT report[1]. General Dynamics asked ABSG Consulting Inc. (ABS Consulting) to review and comment on the report.

[1] BakerRisk, "Potential Explosion Risk Study for Suburban Rail Line Extension", BakerRisk Project 01-1638-001-06, Final Report, September 19, 2008.
[2] NRCAN, "Quantity Distance Principles", Explosives Branch Natural Resources Canada, 1995.

2. AMT Risk Analysis Review

NRCAN Q-D Principles[2] do not discuss risk analysis methods or risk acceptance criteria. It should not be assumed that a risk analysis would be accepted by NRCAN without their endorsement. However, U.S. Department of Defense Explosive Safety Board (DDESB) TP-14 "Approved Methodologies and Algorithms for DoD Risk Based Explosives Siting" contains risk criteria utilized by the DDESB[3]. The associated risk acceptance criteria are presented below in Table 1 for reference. The risk acceptance criteria are broken down for Individual Risk and Group Risk for employees (those voluntarily exposed to explosives hazards) and a non-employee/public (those involuntarily exposed to explosive hazards). According to the DDESB criteria, the risk acceptance level for the passengers of the commuter rail is 1×10^{-6} for Individual Risk and 1×10^{-5} for Group Risk. The AMT risk analysis does not clearly summarize both the Individual Risk and Group Risk to all riders.

Table 1. The DDESB Risk Criteria[3]

Risk to:	Criteria
Any 1 employee (Annual P_f)	• Limit maximum risk to 1×10^{-4}
All employees (Annual E_f)	• Attempt to lower risk to 1×10^{-3} • Accept above 1×10^{-2} with significant national need only
Any 1 non-employee (Annual P_f)	• Limit maximum risk to 1×10^{-6}
All public (Annual E_f)	• Attempt to lower risk if above 1×10^{-5} • Accept above 1×10^{-3} with significant national need only

The risk analysis performed for the AMT report involves three basic components:

1. Probability of an event
2. Probability an individual is exposed to the event
3. Probability of fatality given exposure to the event

ABS Consulting reviewed the AMT risk analysis and have divided our comments regarding the analysis into two categories. The first category of comments relate to the underlying principles of the analysis. The second category involves technical items of lesser importance.

[3] DDESB, "Approved Methodologies and Algorithms for DoD Risk Based Explosives Siting", TP-14 Revision 4, November, 2008.

2.1. Principles of the Analysis

The AMT Risk analysis report does not reference the source document for the risk analysis methodology or frequencies. Table 4 on page 12 of the AMT report appears to be taken from DDESB TP-14, "Approved Methodologies and Algorithms for DoD Risk Based Explosives Siting"; however, the values in the table are not consistent with more recent versions of TP-14.

Based upon the date of the report, September 19, 2008, the 3rd revision of TP-14 dated 2 February 2007 was available and could have been utilized[4]. This revision of TP-14, although not the latest, has frequencies of explosion that differ from those utilized in the AMT report. In addition, two basic principles of the risk analysis should be reviewed for accuracy: (1) Passengers exposed and (2) primary fragments. Each of these is discussed in detail in the following two sections.

2.1.1. Passengers Exposed

The risk analysis assumes a train to carry 256 passengers (see Section 4.1.1 page 13) with a total of 16 trains per day, 5 days per week (see Section 4.4 page 16). Therefore, the total daily passenger load utilized for the AMT risk analysis is 16 trains*256 passengers / train = 4,096 passengers/day. However, based on AMT publicly released information, 6,575 passengers per day will eventually travel through the GD site. The number of passengers expected to travel through GD property is based on a posted number of 2,300 parking spaces to be established in Terrebonne and Mascouche (the two train stations beyond the site on the train path). AMT has specified that parking space shall represent 70% of the passenger load which equates to the 6,575 passenger estimate. Therefore, the probability of an individual being exposed to the event should be modified to reflect the more recent AMT passenger estimates.

The passenger level will also affect the statement that D5 distance is the required separation. Above 5,000 passengers, D7 separation distance would be required.

2.1.2. Primary Fragments

The rail car construction is described in the report as consisting of 12 mm polycarbonate windows and 1/8 inch mild steel skin (see section 3.1 page 4). Risk due to primary fragment penetration (i.e., pieces of the ammunition casing) was neglected due to the penetration resistance of the windows (see section 3.2.1 page 5 and section 4.1 page 10). However, ABS Consulting analysis of the polycarbonate windows utilizing ConWEP[5] showed that the design basis fragment, from detonation of a single M107 round at a range of 300 m, is capable of penetrating the polycarbonate window. Figure 1 shows the results of the ConWEP analysis and notes that the fragment residual velocity is [redacted][6]. This result contradicts the AMT analysis and implies additional risk resulting from primary fragments.

[4] DDESB, "Approved Methodologies and Algorithms for DoD Risk Based Explosives Siting", TP-14 Revision 3, 2 February, 2007.
[5] ConWEP 2.1.0.1, USAE Research & Development Center, 1997.
[6] Sensitive Information. Text obscured for public distribution.

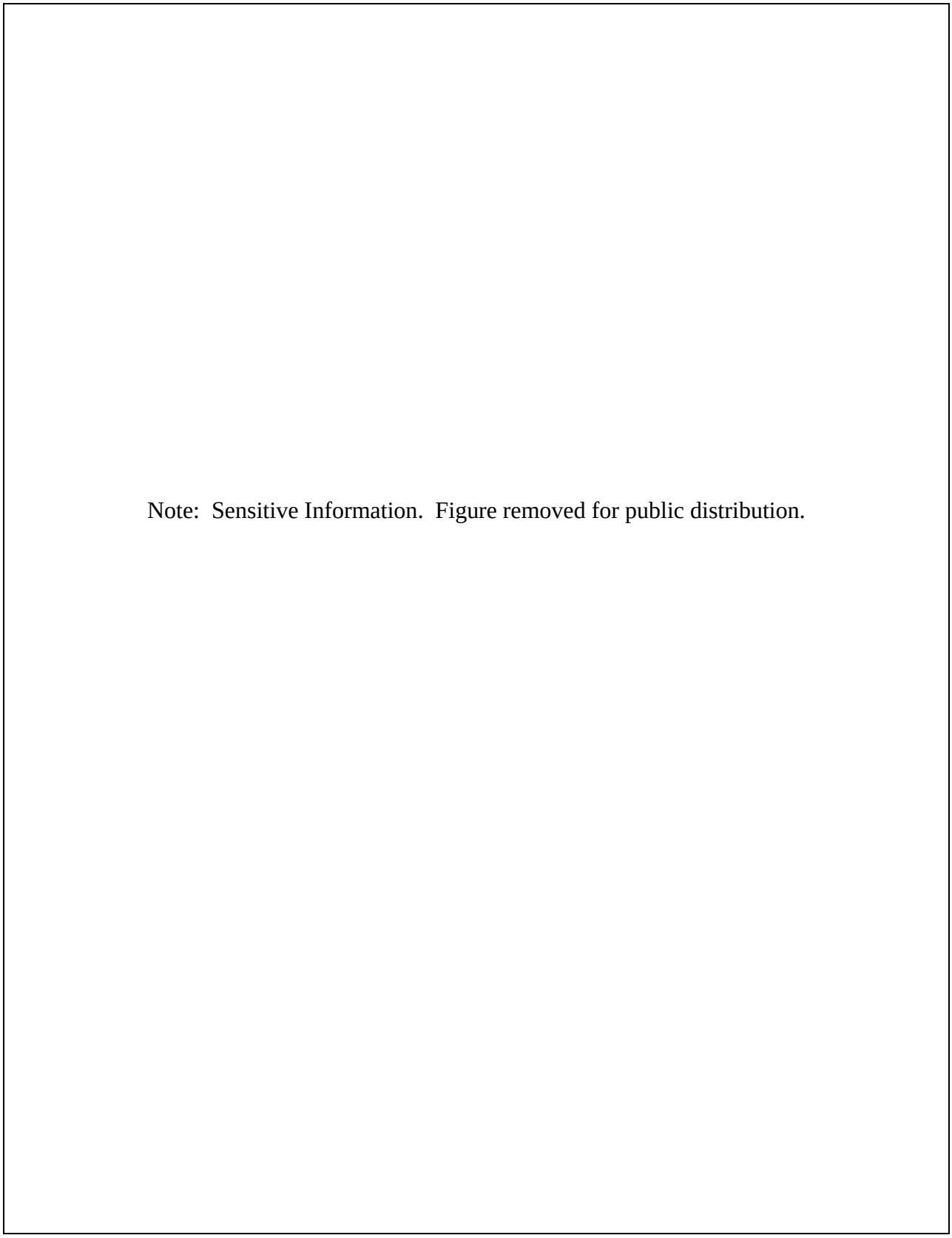

Figure 1. ConWEP[5] Results for Fragment Penetration of 12 mm Lexan Window at 300 m

The AMT analysis considers fragments generated from a single M107 round. Chapter 5 TP-16, "Methodologies for Calculating Primary Fragment Characteristics"[7] contains methodologies for evaluating fragmentation of stacks of munitions. The "stack effect" can increase the initial fragment velocity up to a factor of 2.0. In addition, for stacks of munitions, fragment masses are increased by 50%.

Therefore, the risk to occupants from fragment penetration should be modified to account for:

- Effect of Multiple Round Detonations on Fragment Velocity and Mass, per TP-16 Chapter 5[7].
- Primary fragment penetration of the polycarbonate window.
- Potential primary fragment penetration of 1/8-inch rail car skin after effects of multiple detonations are considered.

2.2. Additional Technical Comments

ABS Consulting has the following additional technical comments concerning the AMT Risk Analysis.

1. Executive Summary
    a. 1st paragraph. "required separation distance is D5"
        i. No substantiation is given for this Q-D separation rather than more restrictive D7.
    b. 3rd paragraph, "a comparison to Canadian passenger train accident statistics and to Quebec road accident statistics shows that the risk to train passengers due to an accidental explosion at the GD site is 3,900 to 30,000 times lower for train car travel over the same distance.
        i. No reference given.
        ii. The risk for rail passengers relative to other rail risk is not necessarily relevant. NRCAN must determine acceptable risk.
    c. Executive Summary Mitigation Discussion on Page ii
        i. D5 stated as the requirement, but D7 is discussed for all of the mitigation measures. This is not consistent.
    d. Footnotes 1&2 on pages i & ii.
        i. Footnote 1 states that D5 is distance required to "most" roads and highways. This is not a proper definition of D5 as it pertains to public traffic routes in the NRCAN Quantity Distance Principles. D5 is the defined requirement for "Medium Traffic" or up to 5,000 vehicles a day.
        ii. Footnote 2 states that D7 distance is the separation required to "very busy roads" and to "buildings where people may assemble". This is not a proper definition of D7 as it pertains to public traffic routes in the

[7] DDESB, "Methodologies for Calculating Primary Fragment Characteristics", TP-16 Revision 3, 18 December 2008.

NRCAN Quantity Distance Principles. D7 is the defined requirement for "Heavy Traffic" or over 5,000 vehicles per day.

iii. The footnote nor the report states that Section C.2.4 of the NRCAN Quantity Distance Principles defines Group 4 as buildings and facilities which require Heavy Traffic Route distances and states examples as including:
   i. main railway line
   ii. highways and major roads
   iii. major navigable waterways; and
   iv. non-vital stocks of fuel

2. Section 2.1 – General Magazines Description
   a. Page 2, last paragraph "distances shown in Table 1 are the shortest distance from the edge of a magazine to the centerline of the proposed rail alignment"
      i. Q-D should be the shortest distance from the edge of the magazine to the edge of the rail line OR to the edge of the rail line right of way.
      ii. Note: Rail line does not meet D5 for 1/3 of PESs considered (5 of 15).
3. Section 3.1 – Rail car construction
   a. Second paragraph – "The window and door glazing is designed to be 'bulletproof' and resist the impacts of 24 lb concrete masonry units."
      i. Bullet proof is not a valid ballistic rating. The ballistic rating should be stated.
      ii. The impact energy of the 24 lb CMU should be specified.
4. Section 4.0 – Risk Evaluation
   a. Page 10, 2nd paragraph, "The risk calculated here represents the probability of a fatality on the proposed commuter train route as a result of an accidental explosion at the GD facility."
      i. The risk only assesses fatality. It is therefore noted the risk of serious injury or minor injury have not been evaluated and represent additional risks.

3. Closure

ABS Consulting has reviewed the AMT Explosive Risk Analysis. In addition to making technical comments, questions pertaining to the basic principles of the risk evaluation were noted. These included:

- Summarizing both Individual Risk and Group Risk
- Provide a list of references and state reference document for frequencies (See Table 4). If reference is TP-14, utilize most recent revision of TP-14
- Exposure should be modified to reflect AMT public estimate of 6,575 passengers per day.
- Probability of fatality of passengers to primary fragments should account for
    - Multiple munitions per TP-16 Chapter 5 guidelines
    - Fragment penetration of 12 mm polycarbonate window
    - Assess potential for penetration of 1/8-inch rail car skin.

Sincerely,

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