

IMESAFR OVERVIEW

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Background **QRA**

The Basics

- QRA = Quantitative Risk Assessment
- IME = Institute of Makers of Explosives
- IMESAFR = IME Safety Analysis for Risk (IMESAFR)

IMESAFR is a QRA tool for the commercial explosives industry.

IME has sponsored the development of IMESAFR; regulators from the U.S. and Canada have been part of the development since the inception of the project.



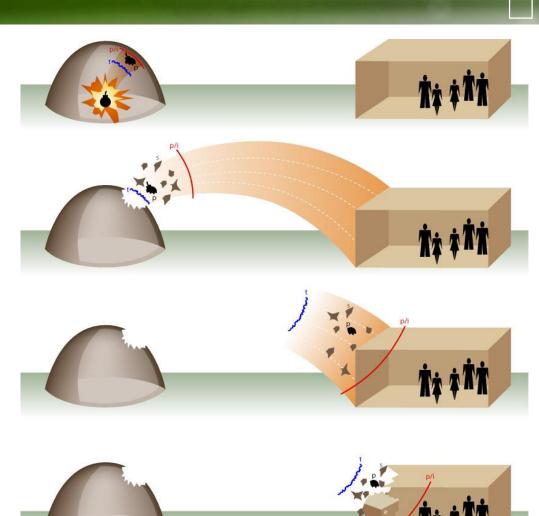
Background **QRA**

Fundamental Math

- Risk = Probability x Consequences
- Consequence includes Exposure

"Effects and Consequences"

- Physical Effects
 - Pressure and Impulse
 - Debris
 - Primary Fragments
 - Secondary Debris
 - Crater Ejecta
 - Thermal
- Consequences
 - Direct Blast
 - Whole Body Displacement
 - Lung Rupture
 - Skull Fracture
 - Structural Response
 - Glass
 - Building Failure
 - Debris (Blunt Trauma)
 - Thermal (Exposure to Instantaneous Radiation)





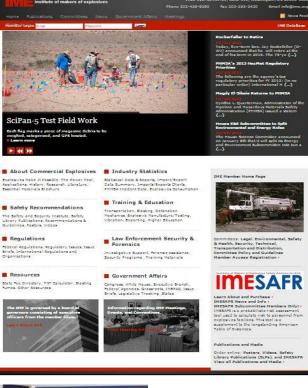
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Background

INSTITUTE OF MAKERS OF EXPLOSIVES (IME)

- IME is the Safety and Security association for the commercial (industrial) explosives industry in the U.S. and Canada since 1913
- Develops recommended practices
- Provides information to legislators, regulators, and law enforcement
- One of IME's original tasks was to create the American Table of Distances (ATD)
- IME member companies produce more than 95% of the commercial explosives used in the U.S.





Videos



Safety Library Publications

Posters



Background INSTITUTE OF MAKERS OF EXPLOSIVES (IME)



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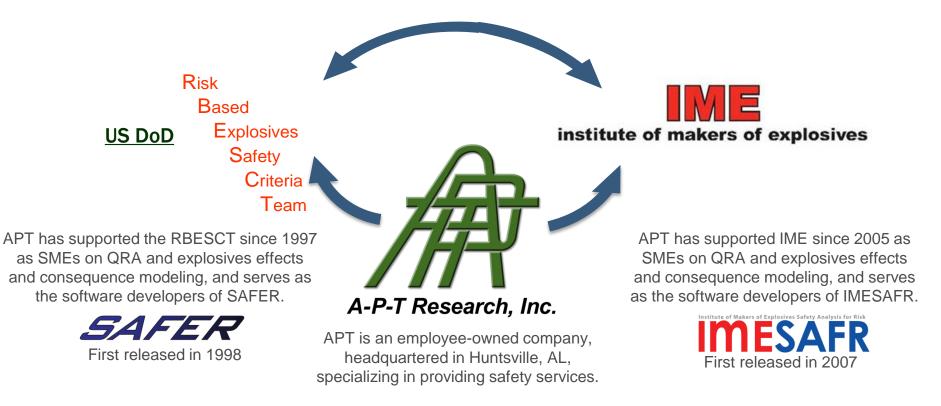
Background

- IME mission is: To promote safety and security and the protection of employees, users, the public and the environment and encourage the adoption of uniform rules in the manufacture, transportation, storage, handling, use and disposal of explosive materials.
- American Table of Distances (ATD) is over 100 years old.
- Over that time explosive products, manufacturing processes, and storage practices changed.
- IME decided to pursue an approach that relied upon quantitative risk assessment (QRA) to determine how and where to store commercial explosives to supplement the ATD.
- IME has since invested in the science of QRA and its continued improvement, knowing it to be a critical component toward advancements in safely storing commercial explosives.



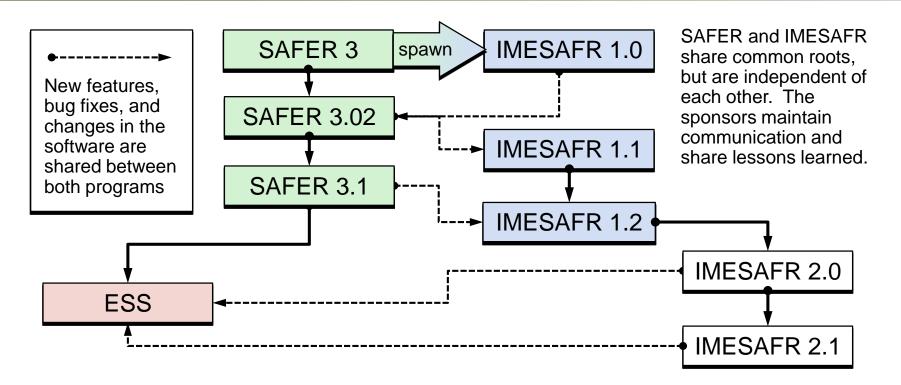
Background **APT**

In 2004, IME recognized that the QRA methodologies and algorithms the Department of Defense (DoD) incorporated into the SAFER (Safety Assessment For Explosives Risk) software tool could benefit explosives risk management for the commercial sector.





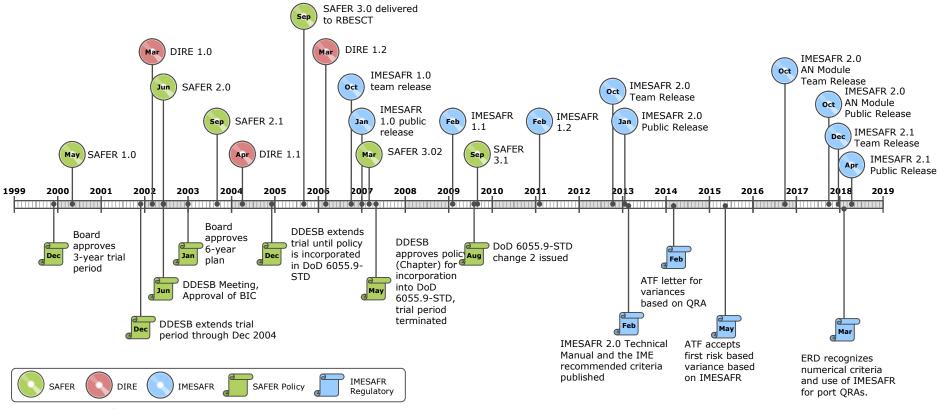
Background IMESAFR PROJECT



While the development of both IMESAFR and SAFER are no longer completely in tandem, continued communication between the IMESAFR and SAFER communities benefits both programs with corresponding developments. When the U.S. DoD moved to a facility database (containing sensitive information) built into their Geographical Information System (GIS) interface, IMESAFR developed a separate GIS interface, introduced in IMESAFR v2.0.



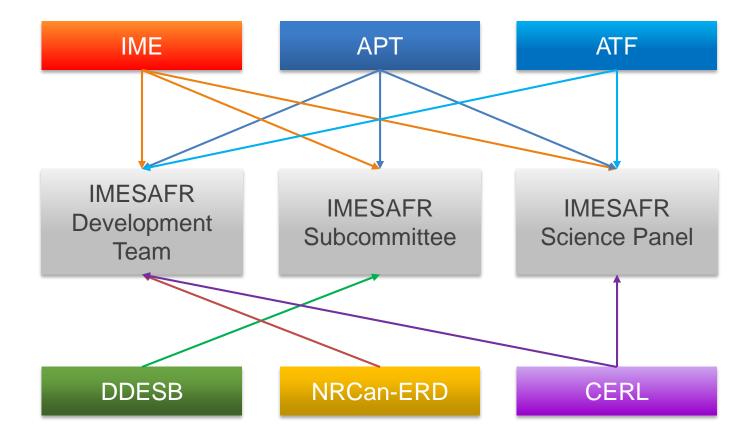
Background **QRA**



Source: A-P-T Research, Inc.

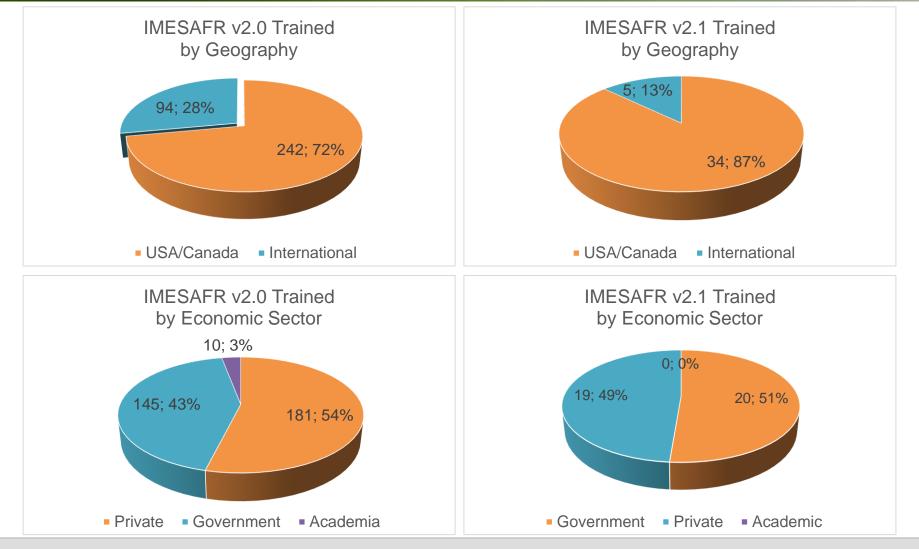


Background **QRA**





Status of v2.1 USERS



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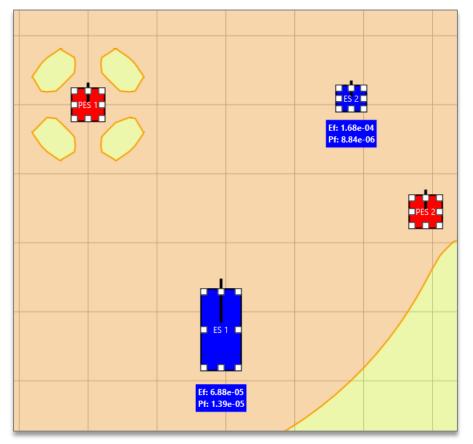


Status of v2.1 TNT ENGINE

IMESAFR v2.1 includes all 2.0 features, as well as updates to algorithms and the software interface.

New Features

- User can now treat a PES as an ES
- Risk contours based on pre-defined ESs
- Barricade options to block vertical and/or side-impact debris
- User-defined risk color coding
- Introduction of Bin G to account for debris that is considered non-hazardous
- User can choose a frangible wall and/or a frangible roof
- QD module now executes SLP 2 QD rules more effectively





Status of v2.1 AN ENGINE

IMESAFR has an Ammonium Nitrate (AN) engine that calculates blast parameters without relying on TNT equivalence logic.

NDIA Paper No. 20701, "Ammonium Nitrate Modeling in the AN Module of IMESAFR," Technical Session – H, Thursday, 10:20-12:00



Status of Regulatory Acceptance **U.S. - ATF**

- ATF currently grants IMESAFR-based variances
- First variance was granted in April 2015
- Eight more IMESAFR-based variances have been approved since then
- ATF currently uses the Risk Bank method to determine if the risk level is acceptable
 - Industry applicants must demonstrate that the risk associated with their scenario is no greater than the risk they would have with a QD-compliant scenario
 - IMESAFR is used to asses both scenarios
- IME has requested that ATF adopt numerical criteria (which would replace the Risk Bank method)
 - ATF requested a peer review of the P(e) logic in IMESAFR, which is being overseen by the IMESAFR Science Panel

NDIA Paper No. 20722, "IMESAFR Science Panel," Technical Track – C, Tuesday, 3:10-4:50

Decision expected later in 2018



- The U.S. Coast Guard (USCG) is looking to follow ATF's lead on QRA for commercial explosives
- Each Captain of the Port (COTP) can decide on the use of QRA now
 - IMESAFR-based variances can be granted; USCG Headquarters encourages COTPs to use QRA for shipments that do not meet QD
 - Buy-in from all involved parties is needed

NDIA Paper No. 20718, "Explosives Safety Risk Assessments at Ports," Technical Track – F, Wednesday, 3:10-4:50



- ERD was accepting QRAs for specific specialist applications, e.g., highway twinning, prior to the development of IMESAFR, but consequence estimation was a limiting aspect.
- NRCan-ERD and CERL have participated in IMESAFR's development since 2005
 - ERD saw IMESAFR as a critical tool in improving, especially, the consequence side of QRAs
 - ERD quotes IMESAFR in both regulations and guidelines as an acceptable QRA tool
 - ERD also mandates the use of IMESAFR or equivalent for some applications for QD derogations (the equivalent of ATF variances)
 - Both CERL and ERD have trained people and use IMESAFR internally

Also used for ports

NDIA Paper No. 20718, "Explosives Safety Risk Assessments at Ports," Technical Track – F, Wednesday, 3:10-4:50



IMESAFR Overview INTERNATIONAL REGULATORY: CANADA (CONT'D)

- QRA and IMESAFR as a QRA tool are broadly accepted by the Canadian explosives regulatory agencies; the initial definition of acceptable risk criteria is particularly promising
- The Canadian Armed Forces (CAF) were interested in the adoption of a quantified risk assessment tool
 - Reviewed the potential of IMESAFR and are now using IMESAFR as part of their Ammunition and Explosives Risk Assessment Safety Case (AERASC) process
 - Several members of the CAF were trained at the recent course in Ottawa
 - The CAF have been asked to provide a nominee for the IMESAFR Development Team and possibly the ISP



IMESAFR Overview INTERNATIONAL REGULATORY: AUSTRALIA

- Australia has a very large AN manufacturing capability and is a very large explosives market serving an economically vital mining sector
- Australia is unusual in that explosives are largely regulated at the State level with only a loose Federal overarching responsibility
- The vast majority of materials manufactured, transported, and stored by the Australian explosives industry (which also manufactures all the AN made in Australia) are classified as HD 5.1 (AN and UN 3375 ANEs); there is no QD required from inventories of HD 5.1 to populations
- Therefore QD is not a major issue in Australia, but risk is
 - No Federal view on QRA for risk management regulation of HD 1.1, 1.5, and 5.1
 - There is no consensus view on QRA on this at the State level
 - Western Australia and, especially, Queensland have taken a proactive interest in QRA and IMESAFR; Queensland is mandating QRAs (using IMESAFR or equivalent) for large ANE inventories
- Australia is moving steadily towards acceptance of QRA and IMESAFR as a QRA tool in, at least, the most important States (as defined by consumption)



IMESAFR Overview INTERNATIONAL REGULATORY: EUROPE

- No CA (Competent Authority) in Europe has formally accepted IMESAFR-supported QRAs from exemptions from QD or other explosives regulations. However, many CAs have been following the development of IMESAFR with interest.
- The Nordics area has a history of accepting QRAs using Amrisk (or Ammorisk), a military explosives risk tool developed by Switzerland et al; they are considering a switch to IMESAFR, now widely used by the regional explosives companies
- Several other CAs in Europe, e.g., BAM (Germany), HSE (UK), Ireland, have accepted QRAs based on IMESAFR analyses for specific sites or regulatory requirements
- IMESAFR is also used to demonstrate compliance to Seveso risk requirements for upper-tier sites with large explosives or AN stores; this is a relatively recent use but is becoming a requirement



TESTING PROGRAM - CONDUCTED

Iron Warrior 4

NDIA Paper No. 20724, "Iron Warrior 4 and Technical Paper 21," Technical Track – D, Wednesday, 10:20-12:00

Derailed

NDIA Paper No. 20737, "IME Derailed Debris Collection," Technical Session – I, Thursday, 1:00-2:40

- IME has provided assistance on several DoD test programs with TP-21 debris recovery efforts
- Data obtained from these tests will be incorporated in IMESAFR



LINKING MODELS TO TESTING SciPan 2 SciPan 3 SciPan 5 SciPan 1 SciPan 4 Input 2. Enter PES. stivity Jan 3. Soluct ES data, exposure dat , calculate Ep Énter explusives lata **IMESAFR** Software calcula > P. ne Exposed Site (ES) es the The explosites data in the inputs include the ES explosive type, the gard Architecture The pote tial E plasio, Site building number, division, lorgan atibility (PES) inpu si clude the building type, roof 1.0 group, indine explo ves building mber, type, ar operc'...g. ours. The prc'ability f event is type, the percentage 26-Step Process weigh and type glass, and the number of persons uculated. present. The personnel exposure is calculated. 4. ulate yield() NEW x K Science 5. Determine open-air P. I 11. Desc the primary flagments 12. Calculate prima y fragmer containme it by PES 19. Determine nominal thermal hazard Vales for pen-air ost P, I) factor numbe of primar fragments and the P/I A thermal hazard aximum the wran le is determined IAW ith DDESB Tec. nic al Paper #16 entage of Grimary fragments pressure c factor based on the are based on ain d by the PES is calculated (G ISO 1p yield and distance between the PES and simplified Kingery Metiodologies / calculating primary ide ng the ercentage of the PES that Bulmast nemispherical agrant chara estics." r act ufter the blast wave. the ES is calculated **F** 13. Reduce number of prinary traging the the PES 14. Fescribe secondary have sta 6. Adias ? I (due to PES) ecta 20. Adjust thermal hazard factor (due to e number of himary fragment that exit The he PES ar calculated based on he percent to the tragments that visre The number of second rate the PES) Computer (BEC) is used Dy PES componei An adjusted thermal o determine the pressure he maimum throw range contain within the pro hazard factor is and impulse values com Jonent) is cal calculated that P'/I' of the PES. The considers the presence of the PES. UK 5 tonne Combine PES debris 15. Define tec a riving debris fragment Kinetic Energy (KE) 9. Determine P, I effer on ES (building ne arrivi 7. Adjust P, due to ES) 21. Determine ES protection We for tables are ummed to form one arriving and glass hazard) SPIDER 3 de pris table A thermal blocking factor that descri ethalit PIN nd crater det is are llapse is ury, second the ** use protection istributed using a t function and stored normal d'aribution provided by the ES is ined. The ercentage calculated. essure and impulse is adjusted aa of the exposed site debrinables. na into account the exposed site damage F SPIDER 2 18 Association 17. Reduce debris due ES 10. Asess Pf(b) LL. ASSESS PI(t) Iron Warrior IV -**-**P ____/ P"// M rw, fw The lethality of thermal The lethality of glass fragments and building sws Pe secondary, and SWG WB \wedge crate def is that penel at is the ES is SPIDER 9.A Nº V The lethality due to lung rupture, whole body collapse is summed. P'/L he lethality of the pertetrating fragments is displacement, and skull fracture is based on Dutch calcul I determined using the RCC debris lethality Sprobit functions. urve. Summation Input, P(e), Exposure Branch 26. Sum E(f) for site. Search for 23. Sum Pie 24. Calc late P/1 25. Wm E(f) from single PES. Effects and Consequence Branch Blast, glass, building collapse, debris, The invividual and group risk Search for maximum P f) for maximum P(f) for site. and thermal levality mechanisms are // pair calculated. Pressure, Impulse Branch PES. summed All cases AII ES. User Glass and Building Failure Branch F $= P_e * P_{f/e} * E_e$ $P_{f/e} =$ The individual nd group risk or a PES The individual and group risk for a site done? done? done? Debris Branch $P_{f(o)} +$ s calculated. is calculated. $(P_{f(0)})(1 - P_{f(0)}) +$ $E_{f(ES)}$ Temperature Branch $E_{f(F,S)} = \sum E_{j(F,S)}$ $E_{f(site)} = \sum_{PES \ sites} E_{f(PES)}$ $(P_{r(d)})(1-P_{-})(1-P_{r(d)})$ Risk Aggregation Branch N of people Next Next $(P_{c(r)})(1 - P_{c(r)})(1 -$ CM-08500 ISO 1 ISO 2 ISO 3 ISO 4 CM-08501

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TESTING PROGRAM - PLANNED

- IME conducted a "maturity matrix" study in 2011, which led to their recommendation of three test series:
 - OH Bin
 - Perforating guns
 - ATF magazines
- The tests will focus on areas that are not priorities to DoD
- IME and ATF hope to conduct the first two of these test programs by 2020



FUTURE PLANS

- Continue to promote the use of QRA for the commercial explosives industry as regulators move away from reliance on QD.
- Facilitate a smooth transition for industry by implementing QD compliance visualization capabilities in IMESAFR.
- Keep working with ATF to determine the best way to use the variance process to manage risk and promote public safety.
- Add features and improve existing algorithms for the worldwide user community.
- Anchor models to test data as the results of new test programs become available, removing undue conservatism in the process.