A-P-T RESEARCH, INC.

AN EMPLOYEE-OWNED COMPANY

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)

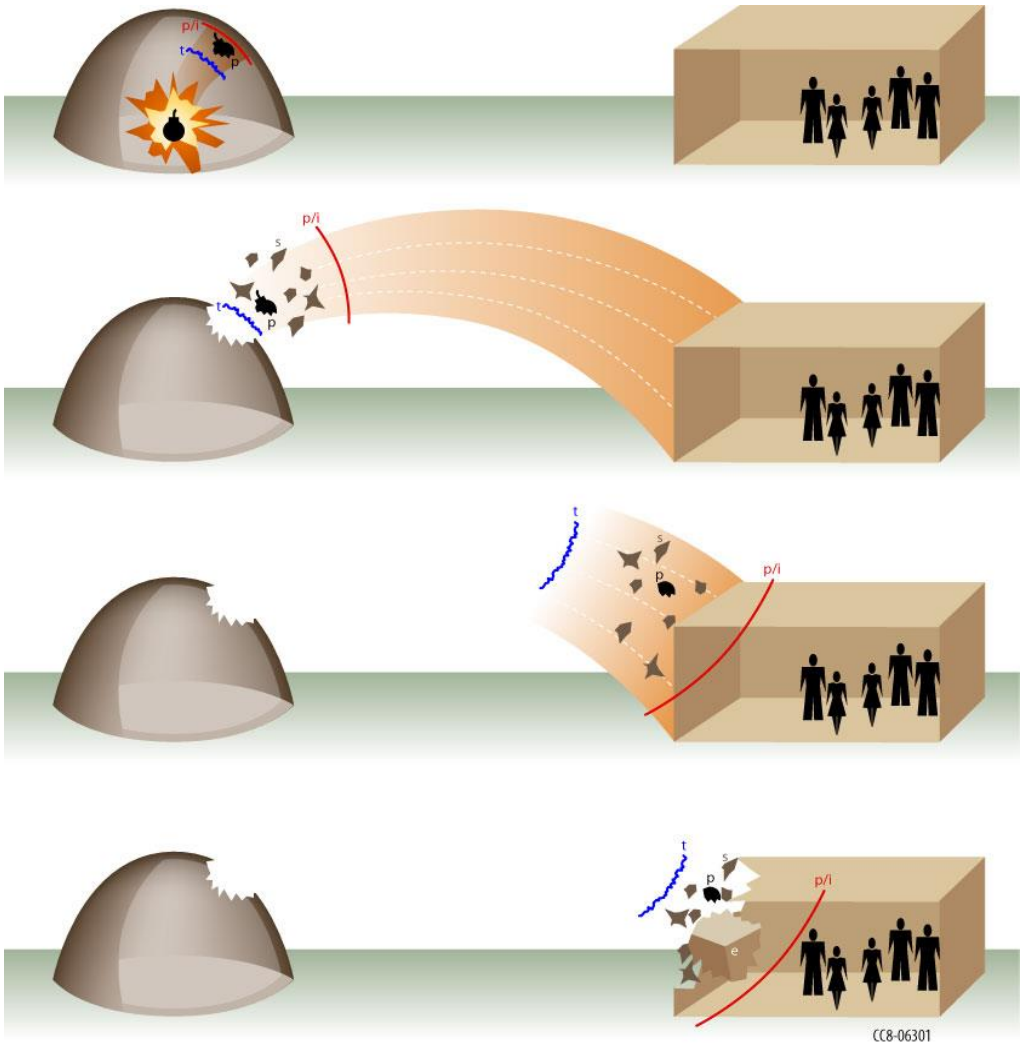
IMESAFR is a QRA tool for the commercial explosives industry.

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

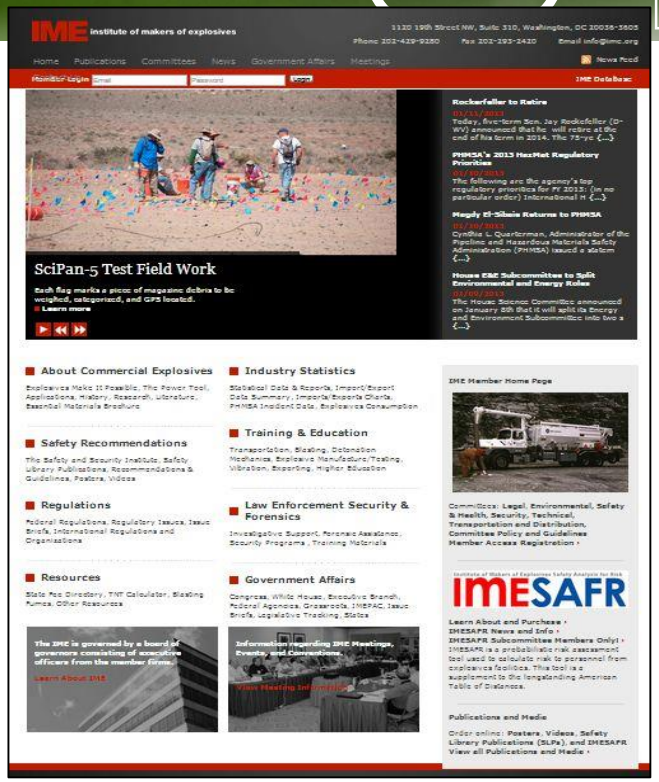
"Effects and Consequences"
- Physical Effects
  - Pressure and Impulse
  - Debris
    - Primary Fragments
    - Secondary Debris
    - Crater Ejecta
  - Thermal
- Consequences
  - Direct Blast
    - Whole Body Displacement
    - Lung Rupture
    - Skull Fracture
  - Structural Response
    - Glass
 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



Background

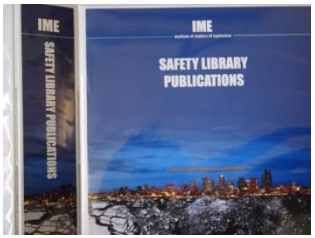
INSTITUTE OF MAKERS OF EXPLOSIVES (IME)

- 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.



Posters

Videos



Safety Library Publications

Background

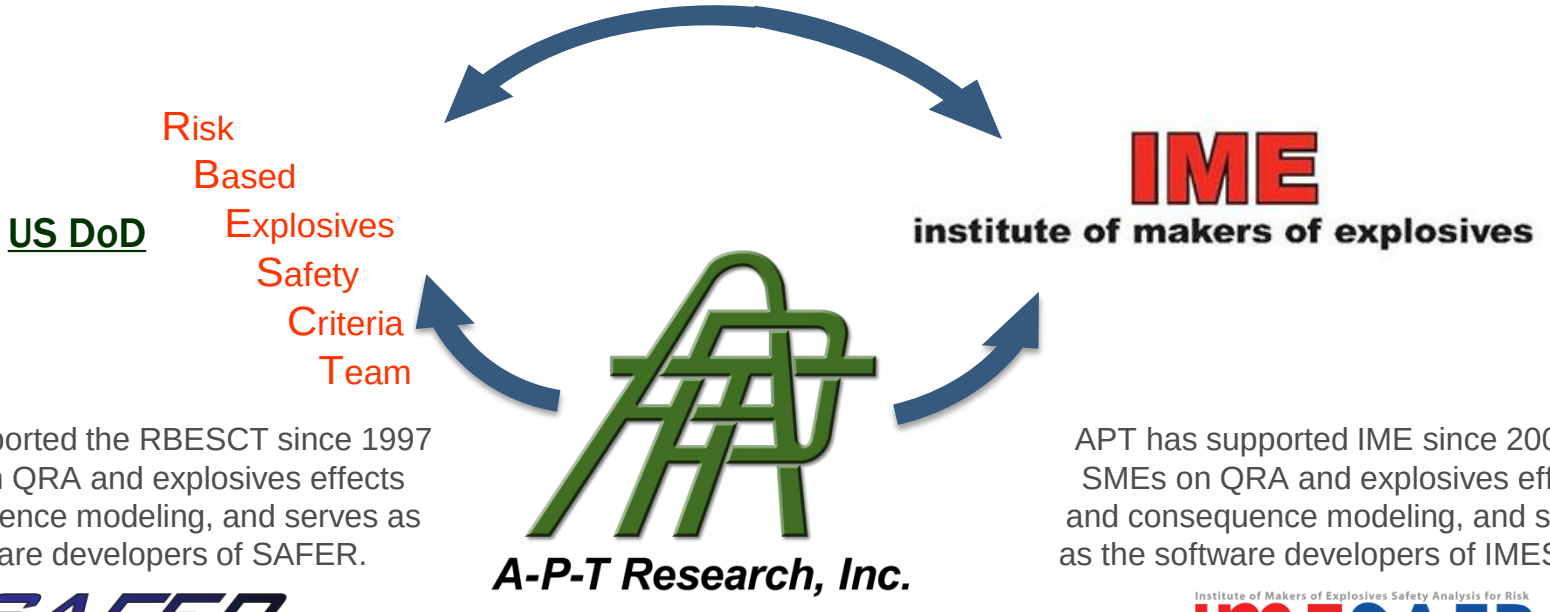
INSTITUTE OF MAKERS OF EXPLOSIVES (IME)

Background
IME

- 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.



APT has supported the RBESCT since 1997 as SMEs on QRA and explosives effects and consequence modeling, and serves as the software developers of SAFER.

SAFER

First released in 1998

APT is an employee-owned company, headquartered in Huntsville, AL, specializing in providing safety services.

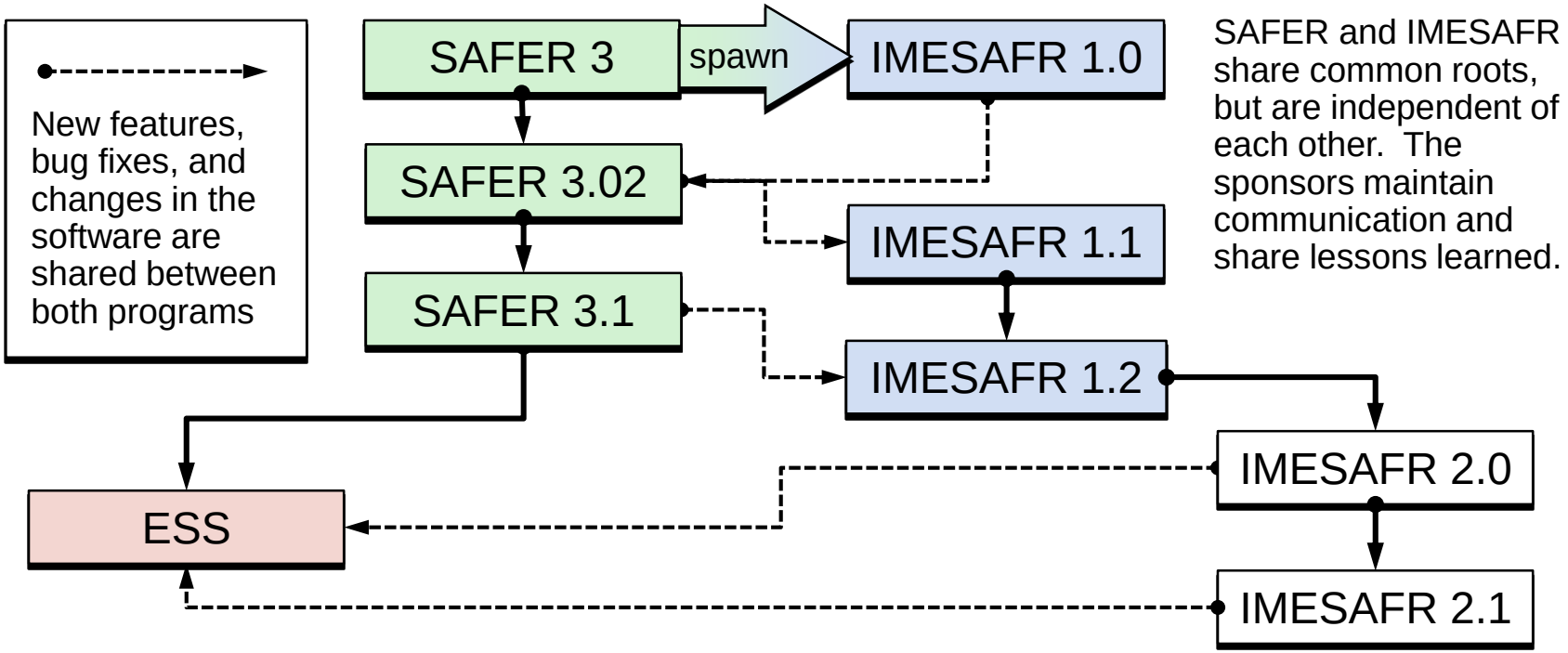
APT has supported IME since 2005 as SMEs on QRA and explosives effects and consequence modeling, and serves as the software developers of IMESAFR.

Institute of Makers of Explosives Safety Analysis for Risk
IMESAFR

First released in 2007

Background

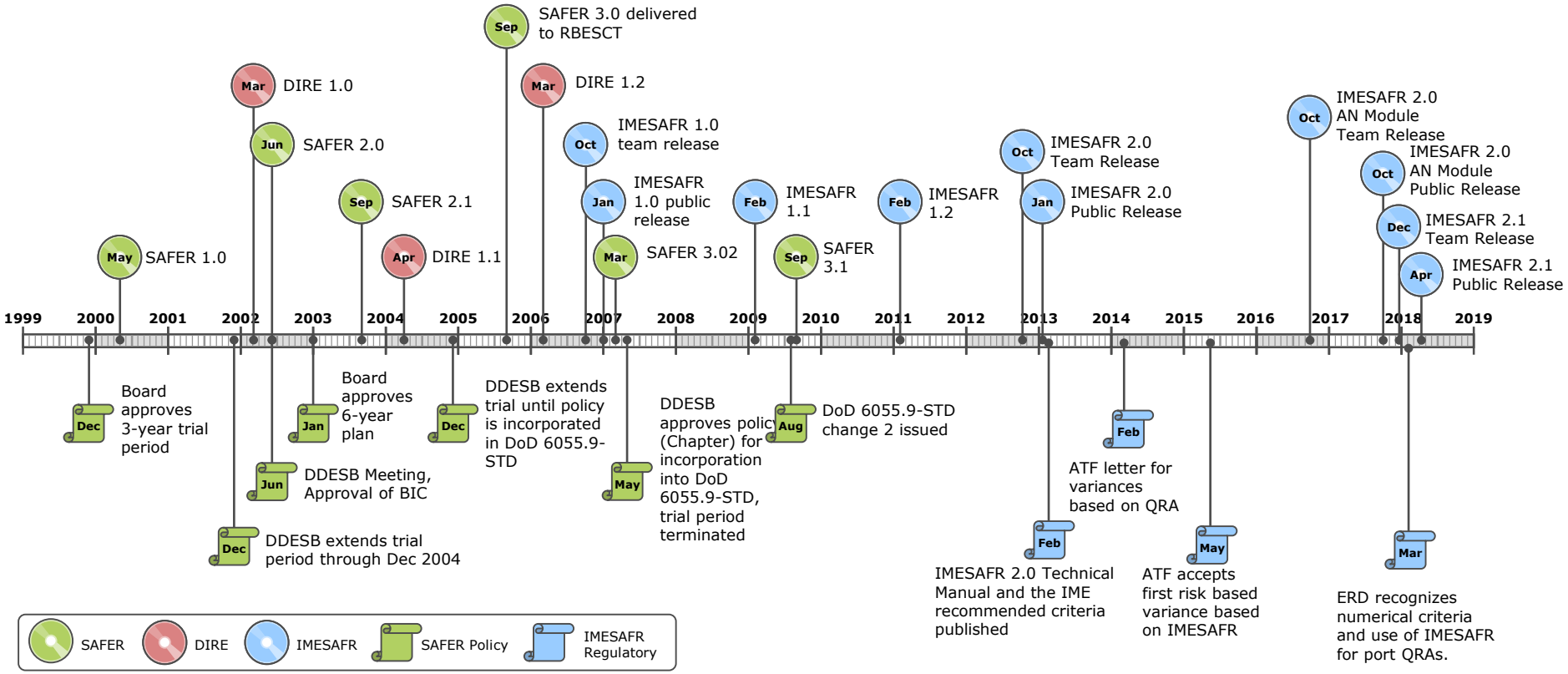
IMESAFR PROJECT



SAFER and IMESAFR share common roots, but are independent of each other. The sponsors maintain communication and share lessons learned.

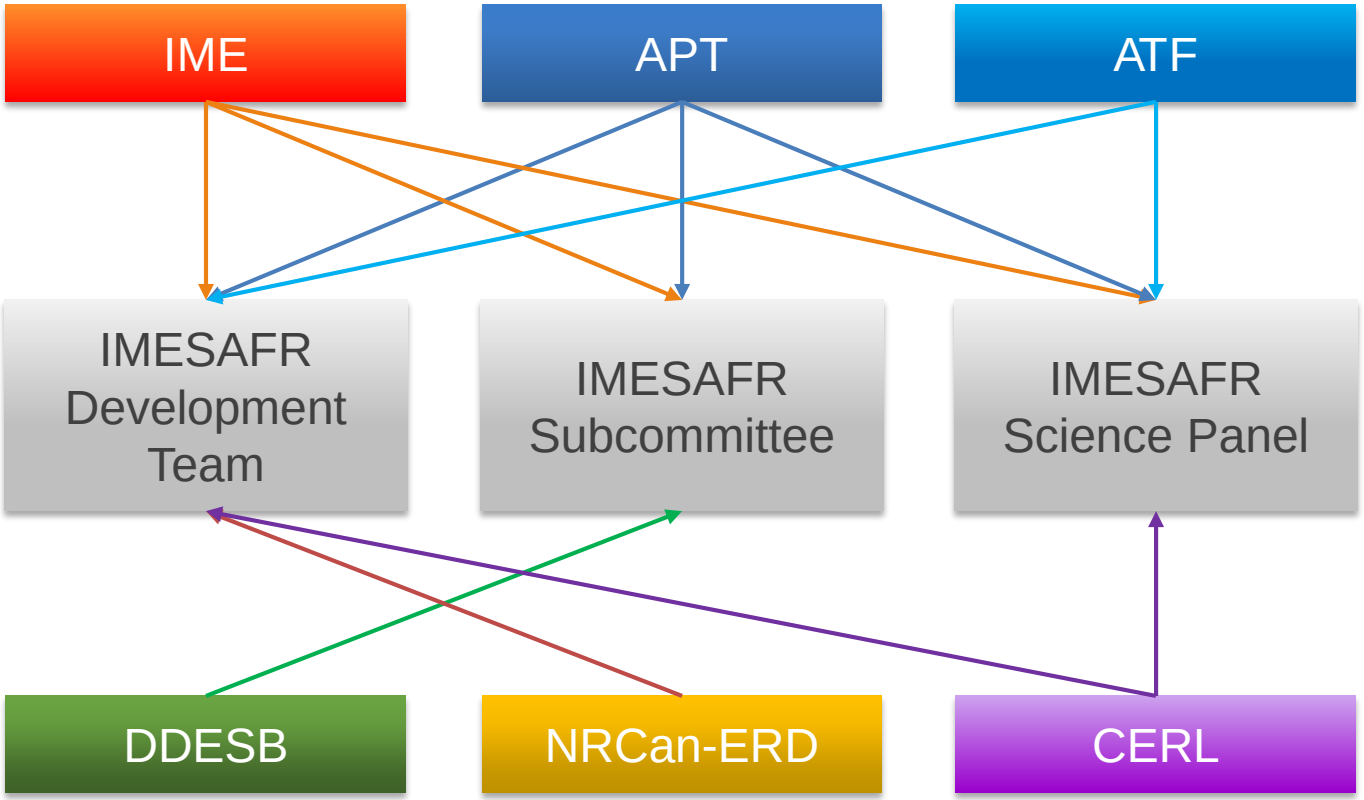
While the development of both IMESAFR and SAFER are no longer completely in tandem, continued communication between the IMESAFR and SAFER communities benefits both programs with corresponding developments. When the U.S. DoD moved to a facility database (containing sensitive information) built into their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

Background
QRA



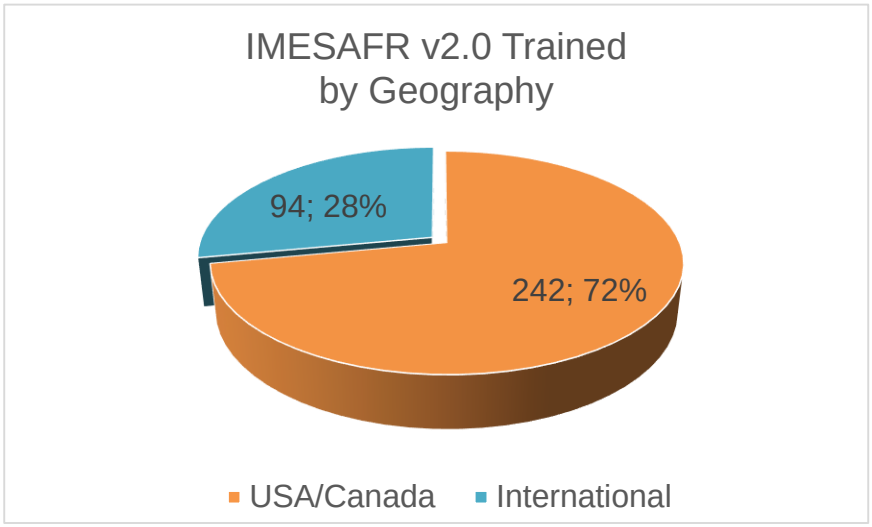
Source: A-P-T Research, Inc.

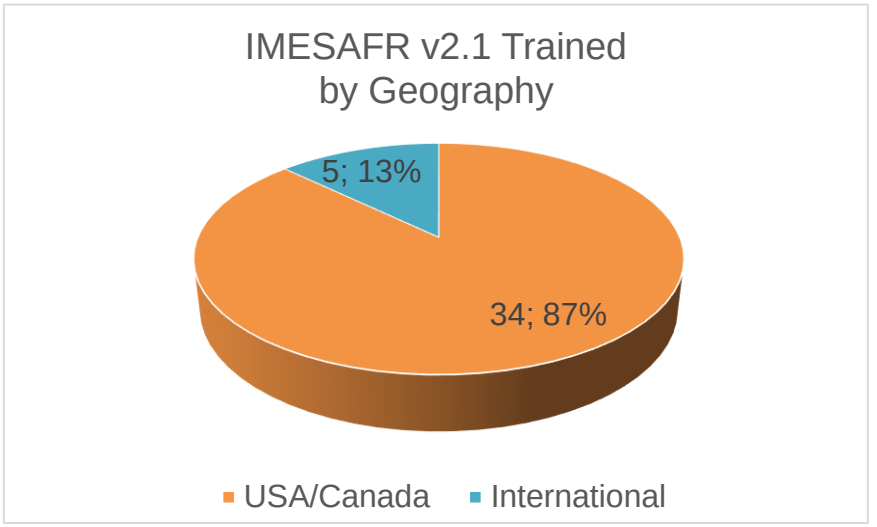
Background
QRA

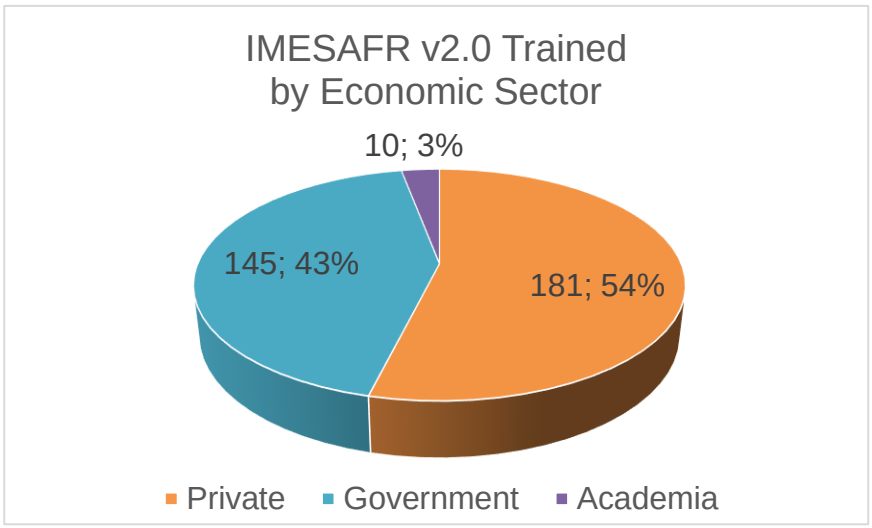


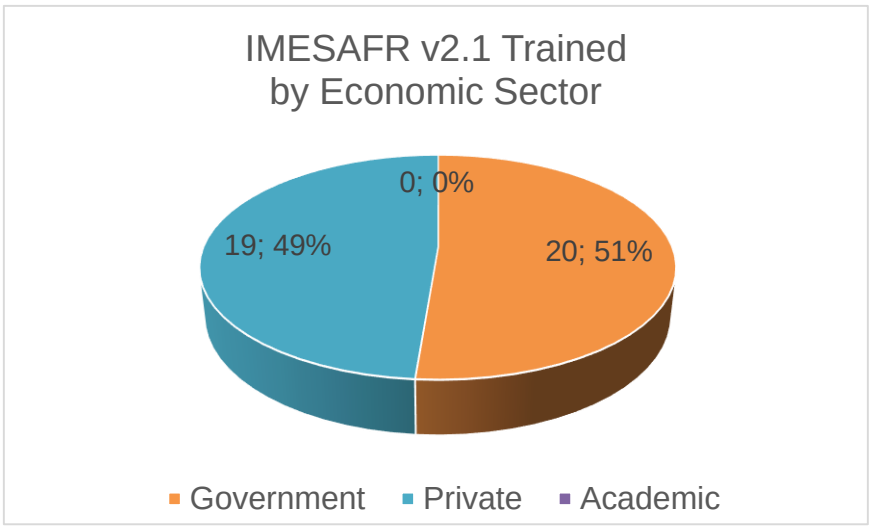
Status of v2.1

USERS









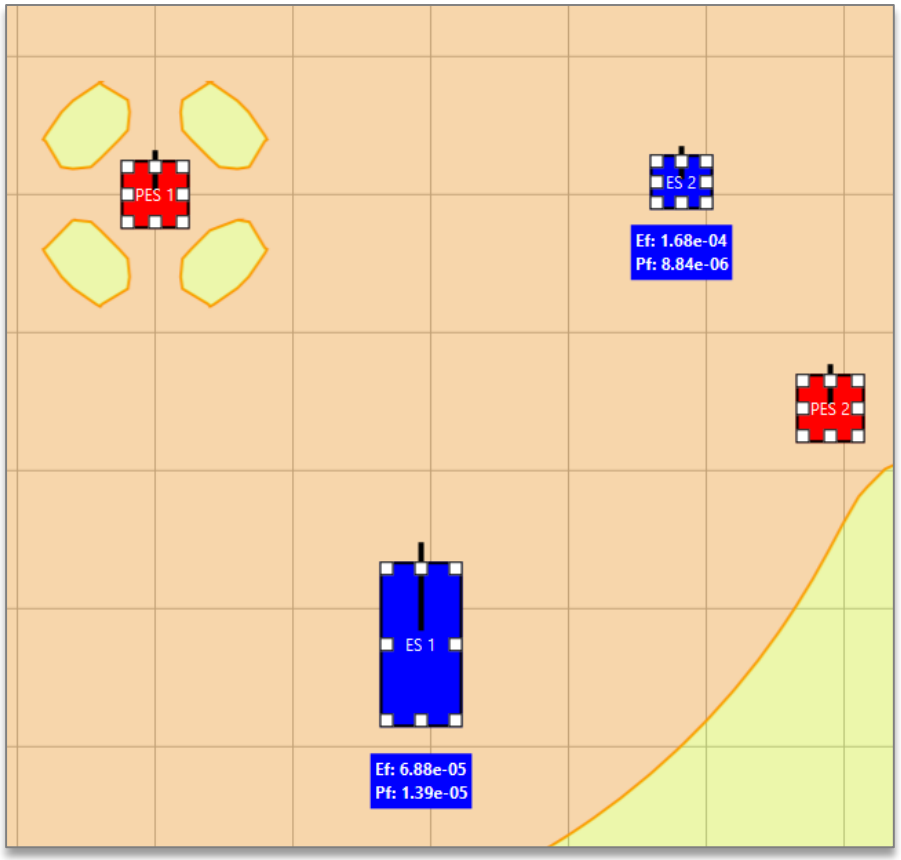
Status of v2.1

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

Status of Regulatory Acceptance

U.S. - USCG

- 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

IMESAFR Overview

INTERNATIONAL REGULATORY: CANADA

- 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

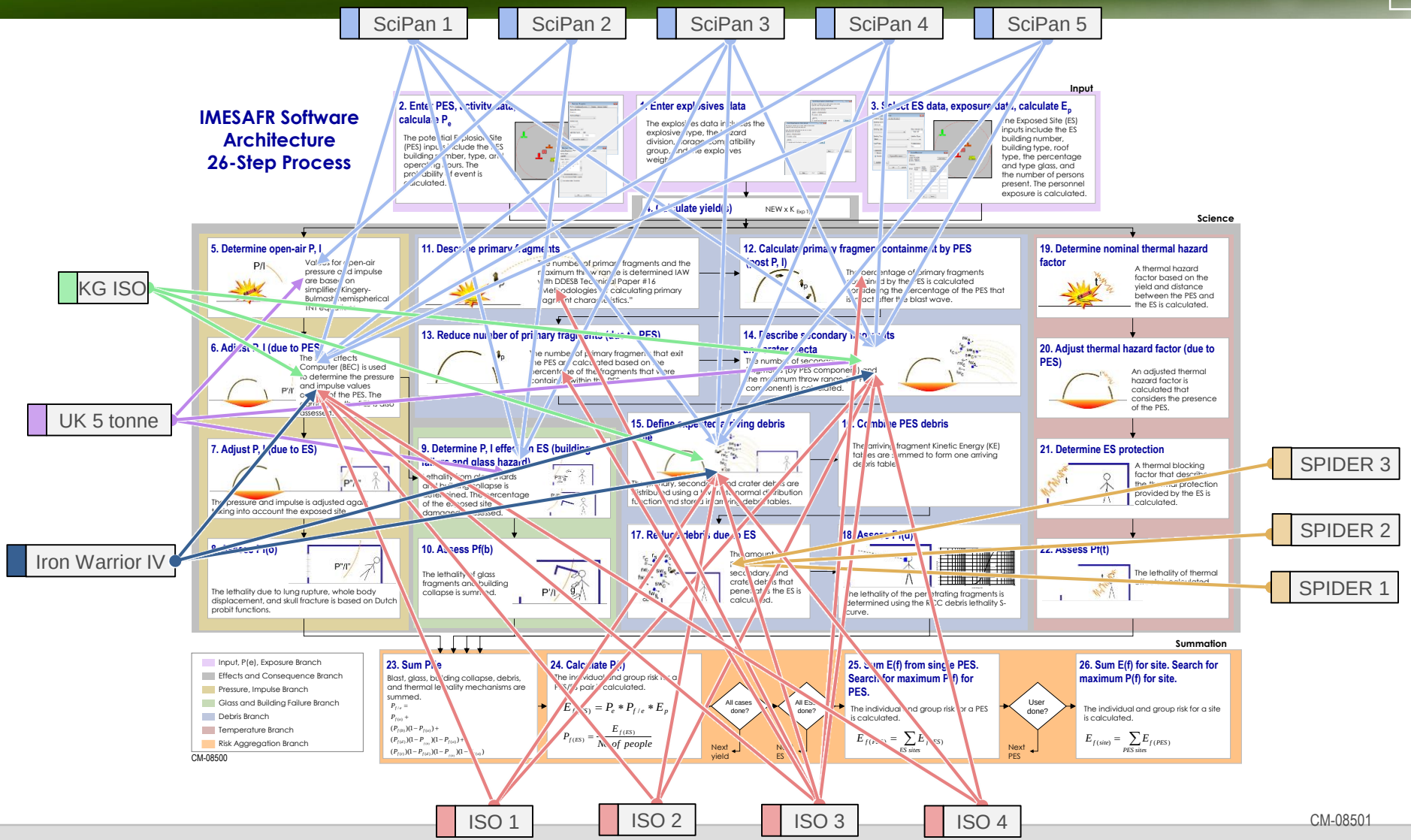
  NDIA Paper No. 20724, "Iron Warrior 4 and Technical Paper 21," Technical Track – D, Wednesday, 10:20-12:00

- 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



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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.