

# **Army Fire Support Investment Framework**

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# Report Documentation Page

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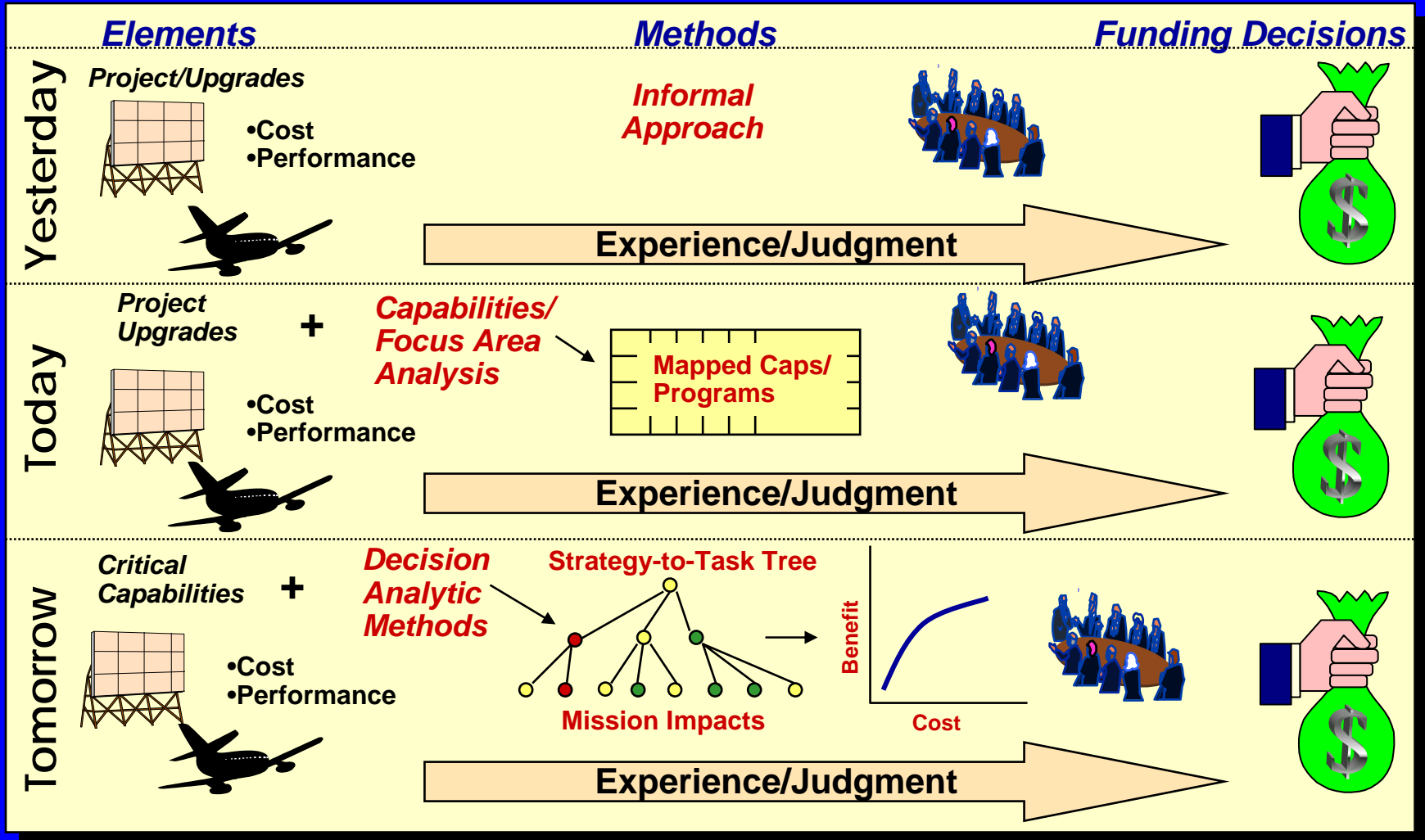
## Goal of the Analysis

**Develop a framework to support System-of-Systems investment decisions using the Army Fire Support Battlefield Operating System as a pilot**

**Concept: *Apply a capability-based analysis approach***

# Background

## Move Towards A Capability-Driven Investment Decision Making



# DoD Guidance for Capability-Based Investment Analysis & Data Sources for Fire Support Mission Breakout

- **Guidance: CJCSI 3170.01C requires implementation of a capabilities-based methodology to support development of integrated architectures.**
  - “The methodology must provide end-to-end traceability of DOTML-PF solutions through the capabilities supported for each Joint Functional Concept.”
- **TRADOC Pamphlet 525-3-9, Future Force Fire and Effects Concept of Operation, September 2003.**
- **FM6-20-10 Targeting Doctrine**
- **Army Precision Engagement (PE) Architecture**
  - **Part of Capabilities-Based Objective Force Architecture developed by Army Architecture Integration Cell**

# Key Tool: The Portfolio AnaLysis Machine (PALMA)

- PALMA is a decision support tool developed by MITRE that facilitates **Capability-Based** investment planning
- Supports an investment strategy *process*
- Brings together:
  - The investment options
  - Their cost
  - What they do for you (detailed impacts)
  - How that fits into your overall goals (mission performance from detailed impacts)
- Finds the best portfolio of investments based on cost and mission-level benefit

# Steps in Applying a Portfolio Analysis Approach

- **Build the mission capability “strategy-to-task” tree hierarchy**
- **Develop “roll-up” performance combination rules from functions to lower-level tasks**
- **Make baseline performance assessments for lowest level tasks**
- **Identify investment options and map their impact to specific tasks in the capability tree**
- **Apply decision analytic methodologies/tools**
- **Gain insights to make investment recommendations**

# PALMA "Tree" Page

**PALM - NotionalPGM7**

File Options Page Options

Data Tree Graph Preprocess Impact

RESULTS

Cost = 4

Benefit = 39

Levels: -1 +1

View: Top Up 1 level Subtree

Battlefield Geo  
 Weather  
 Mapping Sys  
 ThreatAnalysis v1  
 ThreatAnalysis v2  
 ATD Breakout  
 Imaging System  
 Image Annot  
 Mensur Pts  
 Folder Gen v1  
 Folder Gen v2  
 Msn Plan Sys  
 Weaponer Sys  
 AircraftSup v1  
 AircraftSup v2

## Investment Options

## Capability Tree

```

    graph TD
      Root[PGM planning capability] --> C2[Wing/unit level C2]
      Root --> Intel[Intel and targeting]
      Root --> Mission[Mission planning]
      Root --> Support[Support]

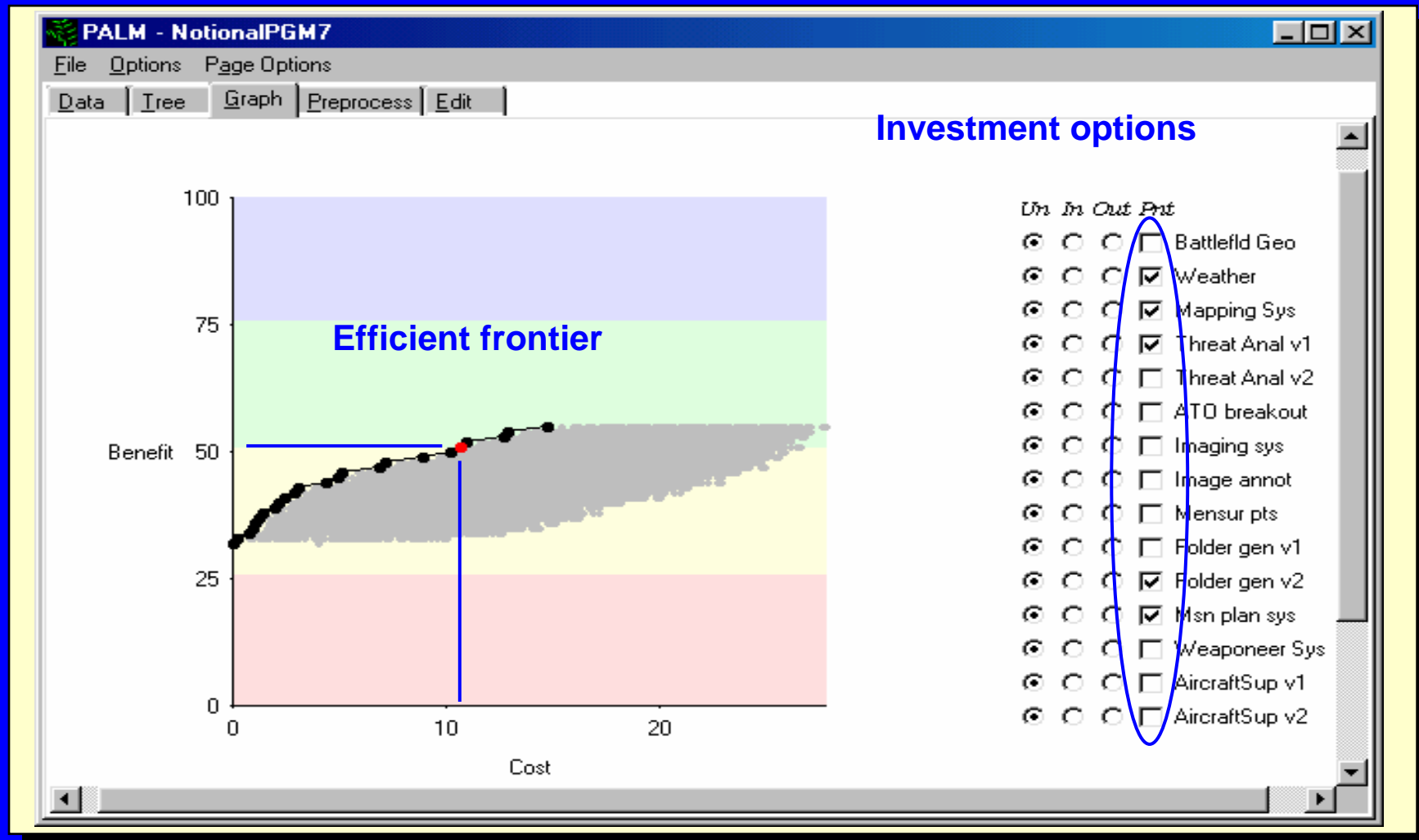
      C2 --> C2_1[ATD rec]
      C2 --> C2_2[ATD bre]
      C2 --> C2_3[Aircraft/ai schedu]
      C2 --> C2_4[Weather]
      C2 --> C2_5[Update databa]
      C2 --> C2_6[Update databa]
      C2 --> C2_7[ATD bre]
      C2 --> C2_8[Threat ar]
      C2 --> C2_9[Aircrew m briefings/re]
      C2 --> C2_10[Battle dar assessment, reporti]
      C2 --> C2_11[ATD bre]
      C2 --> C2_12[Route pla]
      C2 --> C2_13[Weather]
      C2 --> C2_14[Publish m materi]
      C2 --> C2_15[Aircraft]
      C2 --> C2_16[Munitions prep]

      Intel --> Intel_1[ATD breakout]
      Intel --> Intel_2[Plot targets]
      Intel --> Intel_3[Target resear]
      Intel --> Intel_4[ATD breakout]
      Intel --> Intel_5[Plot targets]
      Intel --> Intel_6[Route planning]
      Intel --> Intel_7[Plot targets]
      Intel --> Intel_8[Threat analys]
      Intel --> Intel_9[Calculate laur areas]
      Intel --> Intel_10[PGM flyout]
      Intel --> Intel_11[GPS info]
      Intel --> Intel_12[Publish missi]
      Intel --> Intel_13[Data transfer device materials pre]

      Mission --> Mission_1[Target research prep]
      Mission --> Mission_2[DMPI identification]
      Mission --> Mission_3[Weaponer]
      Mission --> Mission_4[Target folder generation]
      Mission --> Mission_5[PGM flyout prep]
      Mission --> Mission_6[Sensor/sensor model]

      Support --> Support_1[DMPI identification prep]
      Support --> Support_2[Mensuration points]
    
```

# PALMA “Graph” Page





# Plan and Control Fires Subtree

PALMA - Army FDA-G8\_010604\_No\_groups\_colors\_w\_documentation

File Legal Write Mode Adjust Navigate Genetic

Data Tree Graph Preprocess Impact

Node 1.11

ISO Lt forces: AFATDS Effect

abbrev = ISOLtforAF  
color = red  
color# = 17  
rule = \*  
return = 0.1250

Affected by options:  
\*19 AFATDS

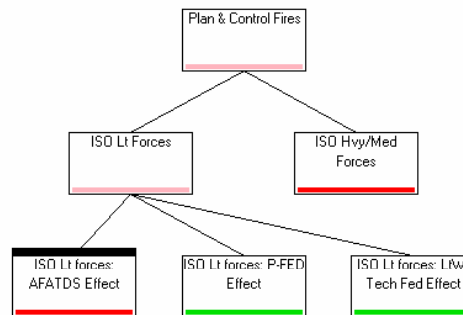
green (83)

B=55, C=2000

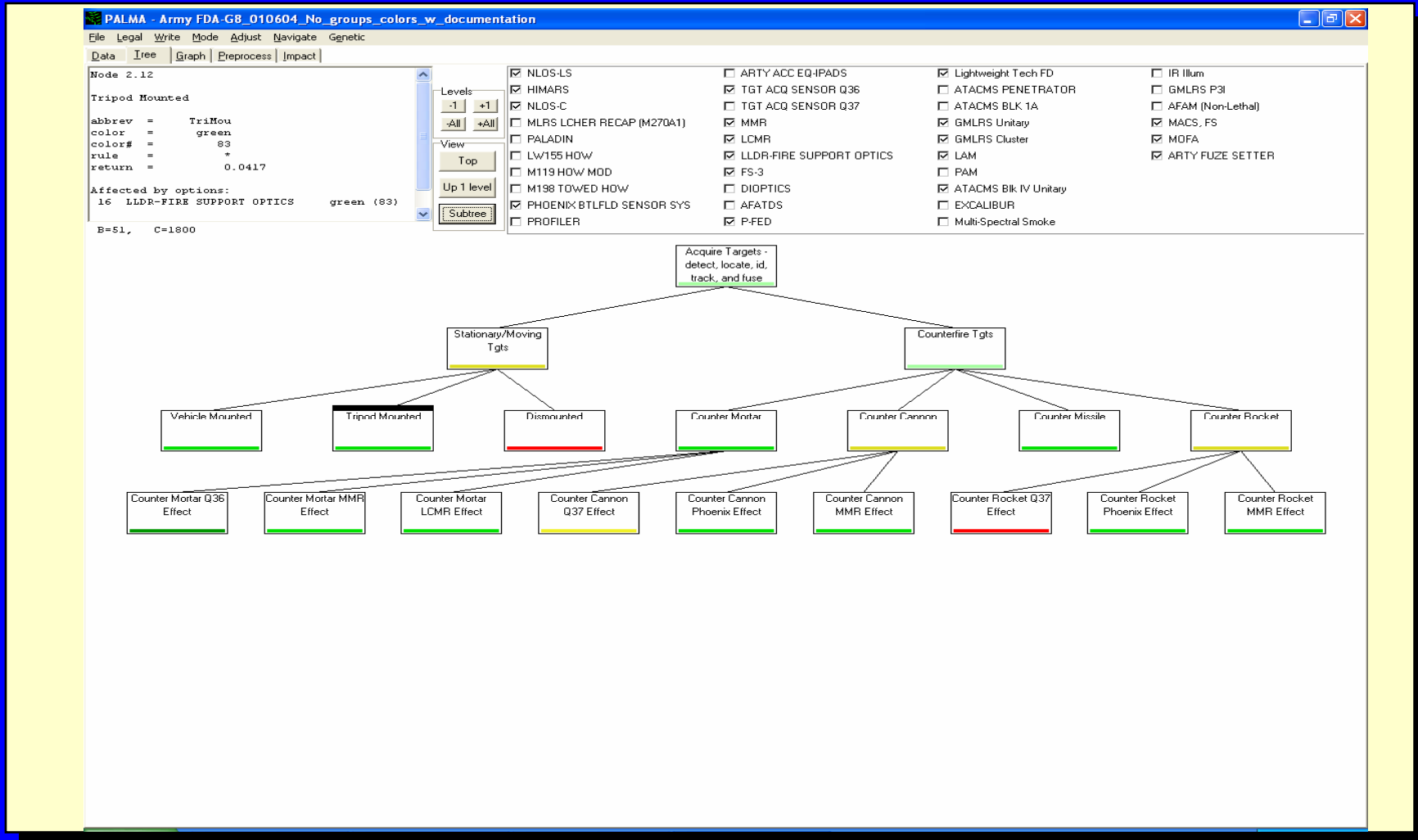
Levels: -1 +1 -All +All

View: Top Up 1 level Subtree

<input checked="" type="checkbox"/> NLOS-LS	<input type="checkbox"/> ARTY ACC EQ-IPADS	<input checked="" type="checkbox"/> Lightweight Tech FD	<input type="checkbox"/> IR Illum
<input checked="" type="checkbox"/> HIMARS	<input checked="" type="checkbox"/> TGT ACQ SENSOR Q36	<input type="checkbox"/> ATACMS PENETRATOR	<input type="checkbox"/> GMLRS P3I
<input checked="" type="checkbox"/> NLOS-C	<input checked="" type="checkbox"/> TGT ACQ SENSOR Q37	<input type="checkbox"/> ATACMS BLK 1A	<input type="checkbox"/> AFAM (Non-Lethal)
<input type="checkbox"/> MLRS LCHER RECAP (M270A1)	<input checked="" type="checkbox"/> MMR	<input checked="" type="checkbox"/> GMLRS Unitary	<input checked="" type="checkbox"/> MACS, FS
<input type="checkbox"/> PALADIN	<input checked="" type="checkbox"/> LCMR	<input checked="" type="checkbox"/> GMLRS Cluster	<input checked="" type="checkbox"/> MOFA
<input type="checkbox"/> LW155 HOW	<input checked="" type="checkbox"/> LLDR-FIRE SUPPORT OPTICS	<input checked="" type="checkbox"/> LAM	<input checked="" type="checkbox"/> ARTY FUZE SETTER
<input type="checkbox"/> M119 HOW MOD	<input checked="" type="checkbox"/> FS-3	<input type="checkbox"/> PAM	
<input type="checkbox"/> M198 TOWED HOW	<input checked="" type="checkbox"/> DIOPTICS	<input checked="" type="checkbox"/> ATACMS Blk IV Unitary	
<input checked="" type="checkbox"/> PHOENIX BTLFLD SENSOR SYS	<input type="checkbox"/> AFATDS	<input type="checkbox"/> EXCALIBUR	
<input type="checkbox"/> PROFILER	<input checked="" type="checkbox"/> P-FED	<input type="checkbox"/> Multi-Spectral Smoke	



# Acquire Targets Subtree





# Engage Targets/Compute Firing Solution Breakout

**PALMA - Army FDA-G8\_010604\_No\_groups\_colors\_w\_documentation**

File Legal Write Mode Adjust Navigate Genetic

Data Iree Graph Preprocess Impact

Node 3.1

Compute Firing Solution

abbrev = ComFirSol  
 color = ylwht  
 color# = 63  
 rule = wgh\_aver[1,1,1,2]  
 return = 0.0938

Rationale:  
 SME Consensus

B=78, C=2400

Levels: -1 +1 -All +All View Top Up 1 level Subtree

<input checked="" type="checkbox"/> NLOS-LS	<input type="checkbox"/> ARTY ACC EQ-IPADS	<input checked="" type="checkbox"/> Lightweight Tech FD	<input type="checkbox"/> IR Illum
<input checked="" type="checkbox"/> HIMARS	<input checked="" type="checkbox"/> TGT ACQ SENSOR Q36	<input type="checkbox"/> ATACMS PENETRATOR	<input type="checkbox"/> GMLRS P3I
<input checked="" type="checkbox"/> NLOS-C	<input checked="" type="checkbox"/> TGT ACQ SENSOR Q37	<input type="checkbox"/> ATACMS BLK 1A	<input type="checkbox"/> AFAM (Non-Lethal)
<input type="checkbox"/> MLRS LCHER RECAP (M270A1)	<input checked="" type="checkbox"/> MMR	<input checked="" type="checkbox"/> GMLRS Unitary	<input checked="" type="checkbox"/> MACS, FS
<input checked="" type="checkbox"/> PALADIN	<input checked="" type="checkbox"/> LCMR	<input checked="" type="checkbox"/> GMLRS Cluster	<input checked="" type="checkbox"/> MOFA
<input type="checkbox"/> LW155 HOW	<input checked="" type="checkbox"/> LLDR-FIRE SUPPORT OPTICS	<input checked="" type="checkbox"/> LAM	<input checked="" type="checkbox"/> ARTY FUZE SETTER
<input type="checkbox"/> M119 HOW/MOD	<input checked="" type="checkbox"/> FS-3	<input type="checkbox"/> PAM	
<input type="checkbox"/> M198 TOWED HOW	<input checked="" type="checkbox"/> DIOPTICS	<input checked="" type="checkbox"/> ATACMS Blk IV Unitary	
<input checked="" type="checkbox"/> PHOENIX BTLFLD SENSOR SYS	<input checked="" type="checkbox"/> AFATDS	<input checked="" type="checkbox"/> EXCALIBUR	
<input checked="" type="checkbox"/> PROFILER	<input checked="" type="checkbox"/> P-FED	<input type="checkbox"/> Multi-Spectral Smoke	

```

graph TD
    A[Compute Firing Solution] --> B[Ensure Accurate Fire Unit Location]
    A --> C[Provide Accurate MET Data]
    A --> D[Provide Accurate System Info]
    A --> E[Automate Computational Efficiency]
    E --> F[Automate Computational Efficiency AFATDS]
    E --> G[Automate Computational Efficiency P-FED]
    E --> H[Automate Computational Efficiency]
  
```

# Engage Targets/Delivery Platforms Breakout

**PALMA - Army FDA-G8\_010604\_No\_groups\_colors\_w\_documentation**

File Legal Write Mode Adjust Navigate Genetic

Data Iree Graph Preprocess Impact

Node 3.4

Delivery Platforms

abbrev = DelPia  
 color = grnio  
 color# = 68  
 rule = wgh\_aver[1,1,1,3,3]  
 return = 0.0938

Rationale:  
 SME Consensus

B=78, C=2400

Levels: -1 +1  
 -All +All

View: Top  
 Up 1 level  
 Subtree

- NLOS-LS
- HIMARS
- NLOS-C
- MLRS LCHER RECAP (M270A1)
- PALADIN
- LW155 HOW
- M119 HOW MOD
- M198 TOWED HOW
- PHOENIX BTLFLD SENSOR SYS
- PROFILER
- ARTY ACC EQ-IPADS
- TGT ACQ SENSOR Q36
- TGT ACQ SENSOR Q37
- MMR
- LCMR
- LLDR-FIRE SUPPORT OPTICS
- FS-3
- DIOPTICS
- AFATDS
- P-FED
- Lightweight Tech FD
- ATACMS PENETRATOR
- ATACMS BLK 1A
- GMLRS Unitary
- GMLRS Cluster
- LAM
- PAM
- ATACMS Blk IV Unitary
- EXCALIBUR
- Multi-Spectral Smoke
- IR Illum
- GMLRS P3I
- AFAM (Non-Lethal)
- MACS\_FS
- MOFA
- ARTY FUZE SETTER

```

graph TD
    DP[Delivery Platforms] --> ISO_Lt[ISO Lt Forces]
    DP --> ISO_Mdm[ISO Mdm Forces]
    DP --> ISO_Hvy[ISO Hvy Forces]
    DP --> ISO_UA[ISO UA]
    DP --> ISO_UE[ISO UE]
    
    ISO_Lt --> L155[ISO Lt forces: LW 155 Effect]
    ISO_Lt --> M119[ISO Lt forces: M119 Effect]
    ISO_Lt --> M198[ISO Lt forces: M198 Effect]
    
    ISO_Mdm --> M119M[ISO Mdm forces: M119 Effect]
    ISO_Mdm --> M198M[ISO Mdm forces: M198 Effect]
    ISO_Mdm --> H155[ISO Mdm forces: LW 155 Effect]
    ISO_Mdm --> H270[ISO Mdm forces: M270 RECAP Effect]
    
    ISO_Hvy --> H155H[ISO Hvy Forces: LW 155 Effect]
    ISO_Hvy --> H270H[ISO Hvy Forces: M270 RECAP Effect]
    ISO_Hvy --> H370[ISO Hvy Forces: TGT ACQ SENSOR Q37 Effect]
    
    ISO_UA --> UANLOSLS[ISO UA: NLOS-LS Effect]
    ISO_UA --> UANLASC[ISO UA: NLOS-C Effect]
    
    ISO_UE --> UE[ISO UE]
  
```



# Battle Damage Assessment Subtree

The screenshot shows a software window titled "PALMA - Army FDA-GB\_010604\_No\_groups\_colors\_w\_documentation". The interface is divided into several sections:

- Menu Bar:** File, Legal, Write, Mode, Adjust, Navigate, Genetic.
- Toolbar:** Data, Tree, Graph, Preprocess, Impact.
- Left Sidebar (Node 4):**
  - Node 4
  - Battle Damage Assessment
  - abbrev = BatDamAss
  - color = green
  - color# = 83
  - rule = average
  - return = 0.0625
  - Rationale: SME Consensus
  - B=51, C=1800
- Central List:** A grid of checkboxes for various assessment items, including NLOS-LS, HIMARS, NLOS-C, MLRS LCHER RECAP (M270A1), PALADIN, LW155 HOW, M119 HOW MOD, M198 TOWED HOW, PHOENIX BTLFLD SENSOR SYS, PROFILER, ARTY ACC EQ-IPADS, TGT ACQ SENSOR Q36, TGT ACQ SENSOR Q37, MMR, LCMR, LLDR-FIRE SUPPORT OPTICS, FS-3, DIDOPTICS, AFATDS, P-FED, Lightweight Tech FD, ATACMS PENETRATOR, ATACMS BLK 1A, GMLRS Unitary, GMLRS Cluster, LAM, PAM, ATACMS Blk IV Unitary, EXCALIBUR, Multi-Spectral Smoke, IR Illum, GMLRS P3I, AFAM (Non-Lethal), MACS, FS, MOFA, and ARTY FUZE SETTER.
- Main Area:** A hierarchical tree diagram showing "Battle Damage Assessment" at the top, branching into "BDA LAM Effect" and "BDA FS-3 Effect".

# Sustain and Resupply Subtree

**PALMA - Army FDA-G8\_010604\_No\_groups\_colors\_w\_documentation**

File Legal Write Mode Adjust Navigate Genetic

Data Tree Graph Preprocess Impact

Node 5

Sustain & Resupply

abbrev = Sus&Res  
color = green  
color# = 83  
rule = min  
return = 0.0625

Rationale:  
Need both options for green; red without both options  
B=51, C=1800

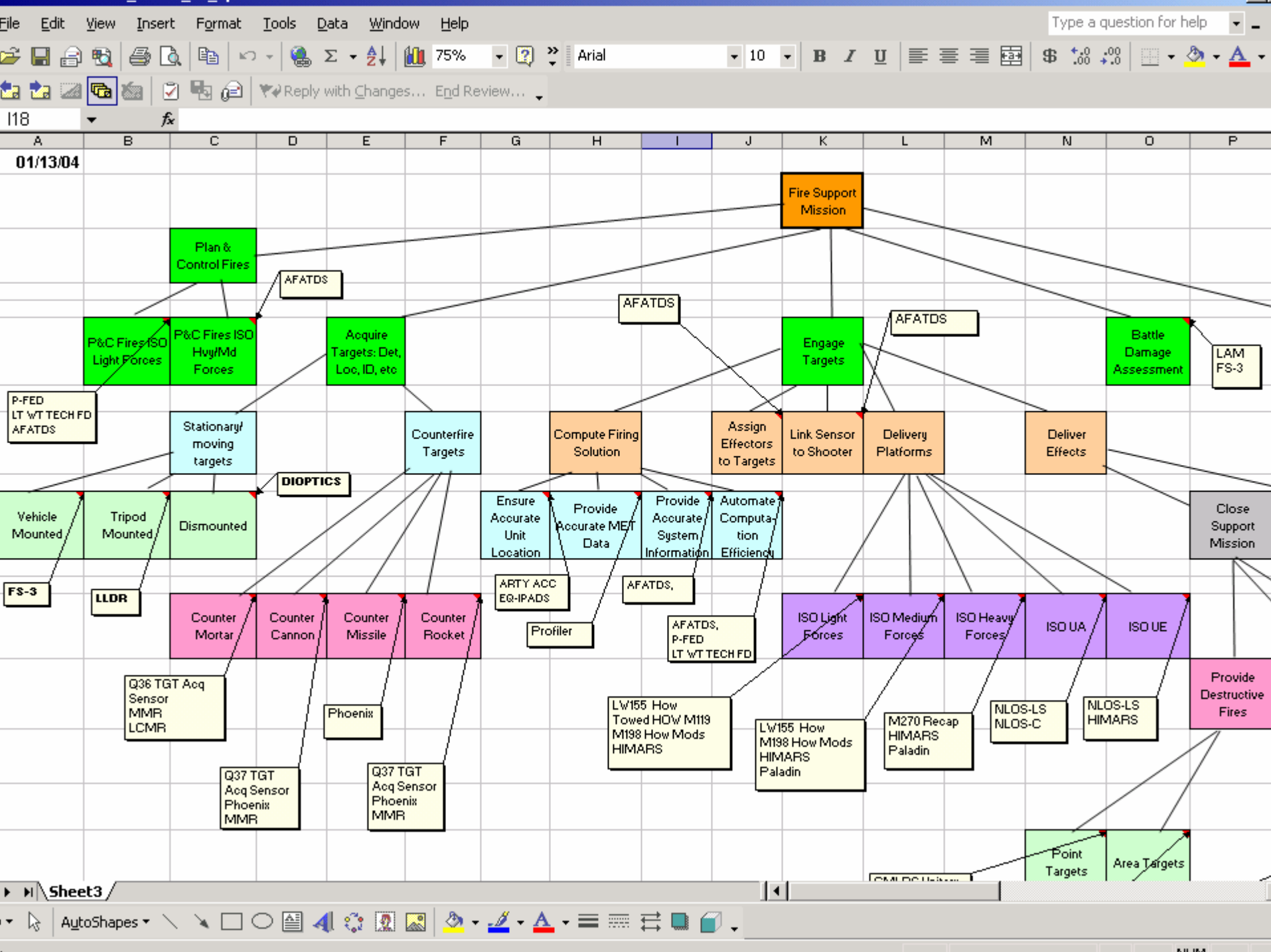
Levels: -1 +1 -All +All

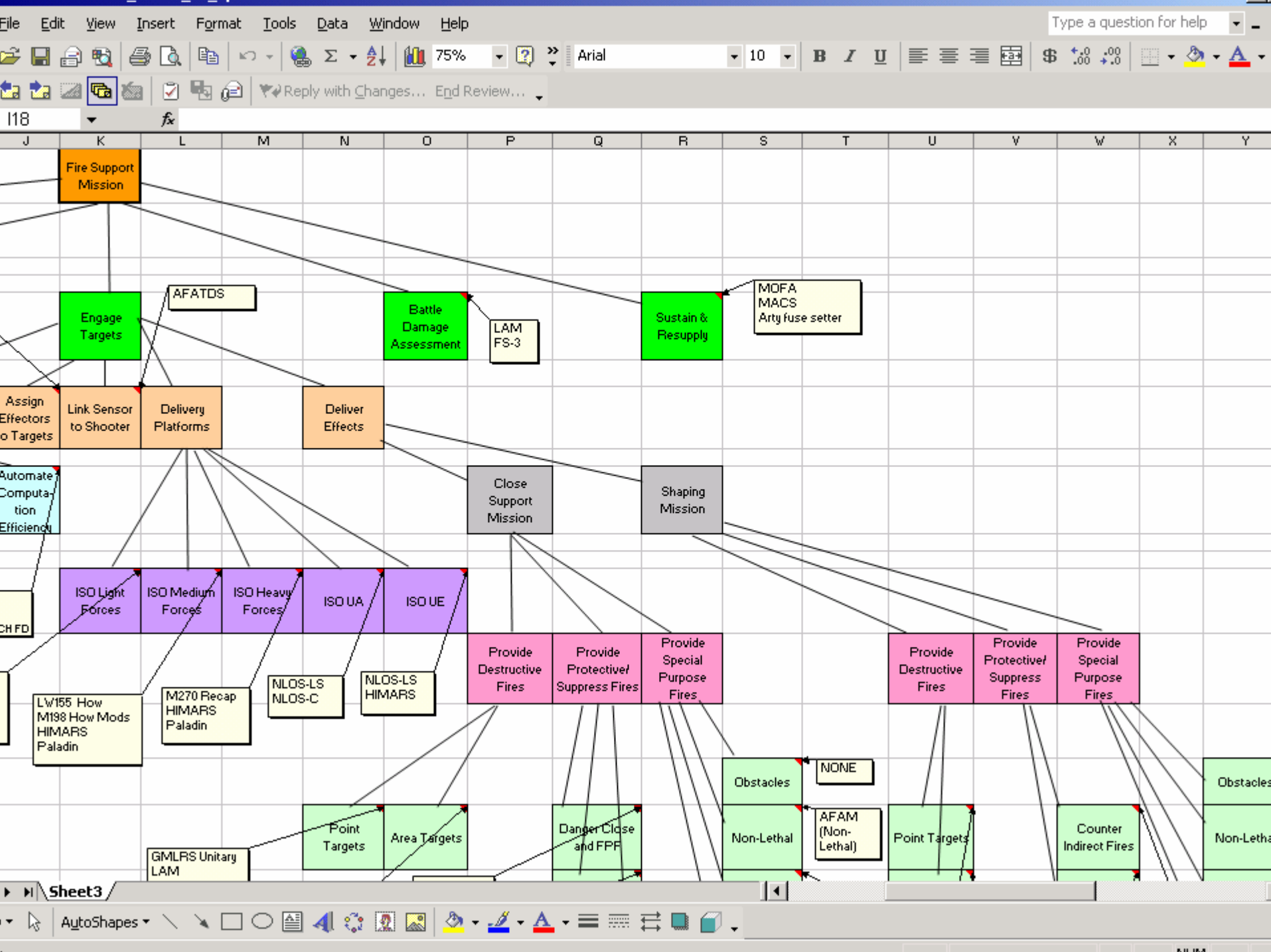
View: Top Up 1 level Subtree

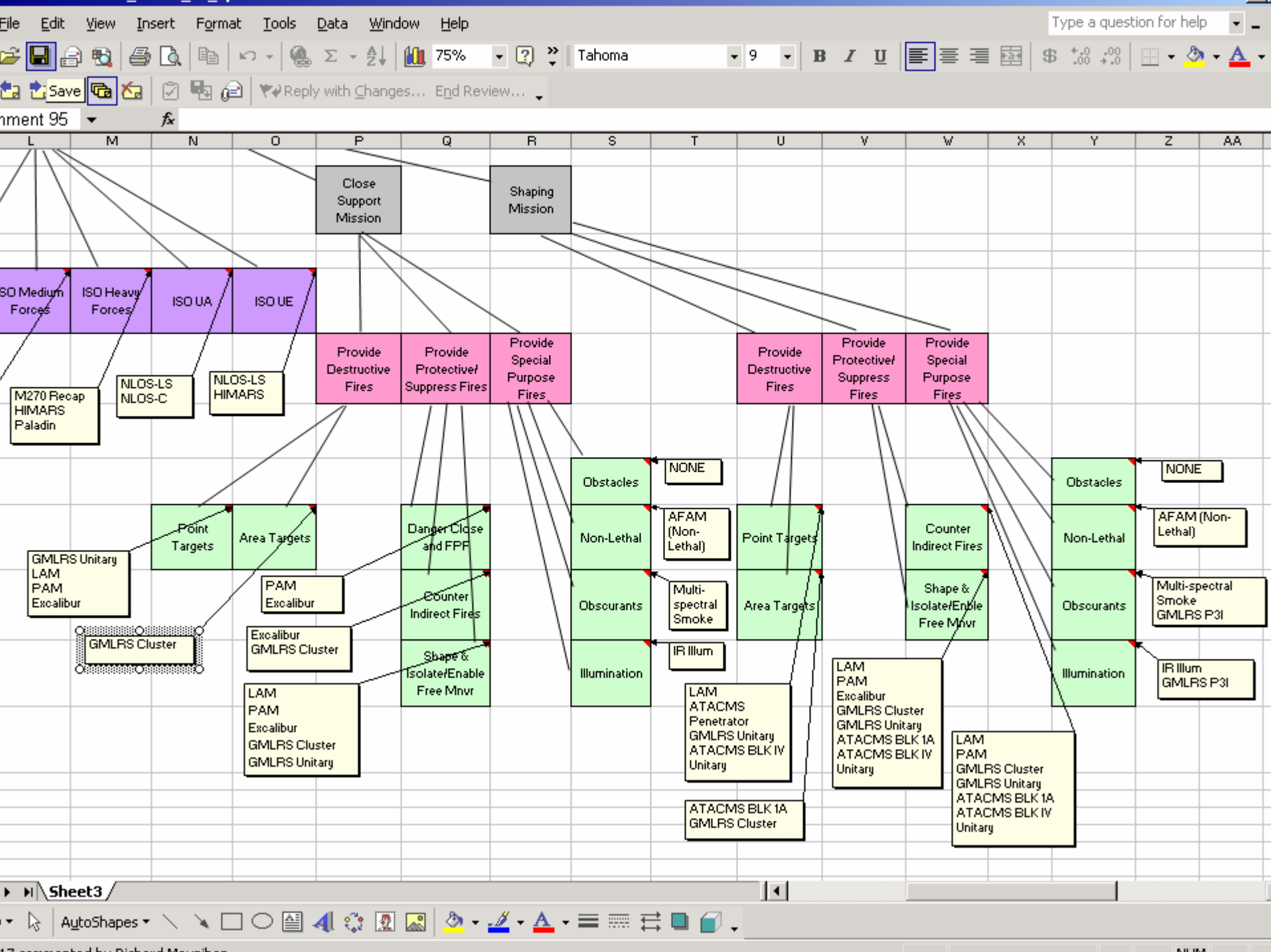
<input checked="" type="checkbox"/> NLOS-LS	<input type="checkbox"/> ARTY ACC EQ-IPADS	<input checked="" type="checkbox"/> Lightweight Tech FD	<input type="checkbox"/> IR Illum
<input checked="" type="checkbox"/> HIMARS	<input checked="" type="checkbox"/> TGT ACQ SENSOR Q36	<input type="checkbox"/> ATACMS PENETRATOR	<input type="checkbox"/> GMLRS P3I
<input checked="" type="checkbox"/> NLOS-C	<input type="checkbox"/> TGT ACQ SENSOR Q37	<input type="checkbox"/> ATACMS BLK 1A	<input type="checkbox"/> AFAM (Non-Lethal)
<input type="checkbox"/> MLRS LCHER RECAP (M270A1)	<input checked="" type="checkbox"/> MMR	<input checked="" type="checkbox"/> GMLRS Unitary	<input checked="" type="checkbox"/> MACS, FS
<input type="checkbox"/> PALADIN	<input checked="" type="checkbox"/> LCMR	<input checked="" type="checkbox"/> GMLRS Cluster	<input checked="" type="checkbox"/> MOFA
<input type="checkbox"/> LW155 HOW	<input checked="" type="checkbox"/> LLDR-FIRE SUPPORT OPTICS	<input checked="" type="checkbox"/> LAM	<input checked="" type="checkbox"/> ARTY FUZE SETTER
<input type="checkbox"/> M119 HOW MOD	<input checked="" type="checkbox"/> FS-3	<input type="checkbox"/> PAM	
<input type="checkbox"/> M198 TOWED HOW	<input type="checkbox"/> DIOPTICS	<input checked="" type="checkbox"/> ATACMS Blk IV Unitary	
<input checked="" type="checkbox"/> PHOENIX BTLFLD SENSOR SYS	<input type="checkbox"/> AFATDS	<input type="checkbox"/> EXCALIBUR	
<input type="checkbox"/> PROFILER	<input checked="" type="checkbox"/> P-FED	<input type="checkbox"/> Multi-Spectral Smoke	

```
graph TD; A[Sustain & Resupply] --> B[Sustain & Resupply MOFA Effect]; A --> C[Sustain & Resupply MACS Effect];
```

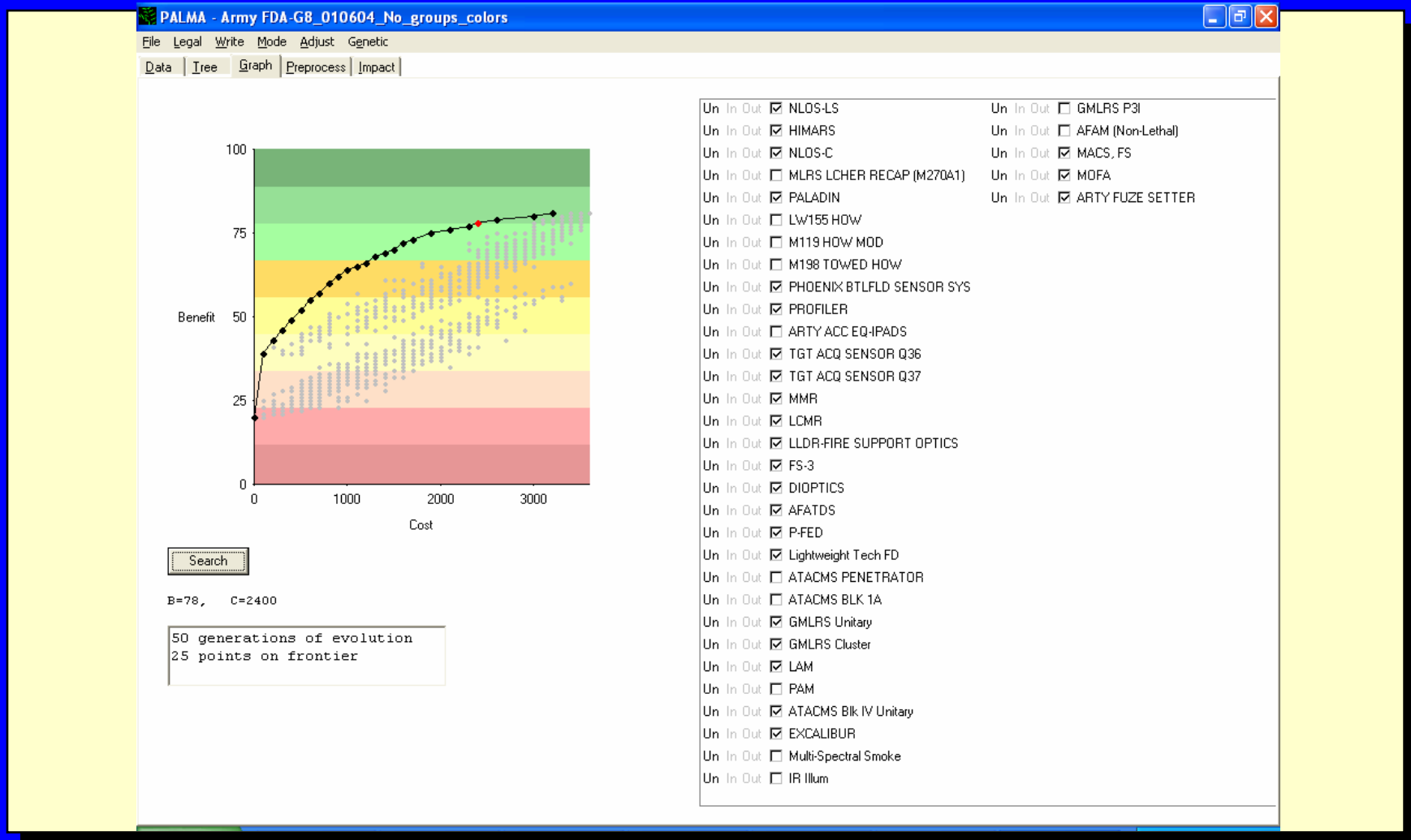
# Matching of Systems to PALMA Leaf Nodes







# Efficient Frontier for Fire Support Mission



# Additional PALMA Functionality

- **Multi time period capability**
- **Accounting for dependencies between investment options (ex: If you procure LAM, you must also procure NLOS-LS)**
- **Ability to portray levels within a color band (“high yellow”, “low green” etc.)**
- **Addition of new roll-up rule functions (lim average)**
  - **Example: Under “Provide Destructive Fires: Point Targets” can represent SME judgment that “I’m Red unless I have both GMLRS Unitary and ATACMS Block IV Unitary systems, but need ATACMS Penetrator and LAM to reach full (Green) capability”**

# Why a Portfolio Analysis Approach?

***With appropriate up-front investment of time and resources, portfolio analysis can be an integral component of effective budget planning and mission thread analysis***

- Forcing-function for detailed assessment/decomposition of mission
  - Provides a structure that pulls in results from other architecture studies and detailed mission analyses
  - Provides an intuitive visual representation of mission
  - Supports dialog across stakeholder groups
- Can be used for quick what-ifs and sensitivity analyses after initial recommendation/assessment developed
- May only need to be “tweaked” to be relevant across years