Skagerrak Code Overview

1 Introduction

Skagerrak is (or was) a computer simulation of WWI fleet actions in the North Sea. It was written for the TRS-80 and then for the Atari ST in the 1980s. The current code is a miniature support program covering fleet actions from about 1900 to 1920 for the fleets of Austria-Hungary, Britain, France, Germany, Italy, Japan, Russia and the United States. It uses the macro language of the LibreOffice Calc spreadsheet program, Version 6.4.7.2.

The code is divided into three separate spreadsheet documents. The first generates scenario files. The second reads a scenario file and is run during the game. The third reads data files written during the game and generates movement plots and gunnery logs for after action reports. Only the game spreadsheet is described herein.

2 Game Setup

2.1 Scenario Load

A scenario file is selected from those created by the scenario spreadsheet. The file specifies date, time, weather (including variability), visibility (including variability), shorelines, obstructions (islands, shoals, minefields), forces, ships, units, positions, courses, speeds, stations, ship efficiencies and date-dependent class data.

Ships are divided into two sides and up to three forces per side. Ships in side 1 (forces 1, 2, 3) will consider ships in side 2 (forces 4, 5, 6) as enemy and vice-versa.

2.2 Initial Outputs

Output files are created for each force, for the narrative and for the plot data. The force output files have the limited information which the players will use to decide on their orders.

2.3 Simulation Inputs

The algorithms for sighting, firing, weapon performance, damage and movement contain a large number of adjustable values. These may be changed via spreadsheet cells.

2.4 Doctrine Inputs

Doctrine choices for each side may be changed for fire distribution, targeting, shell selection, open fire range, torpedo launch and retreat conditions.

2.5 Operational Inputs

If the scenario specifies operational movement, the positions of the waypoints and the speeds are entered for each force. At the last waypoint the force will execute a square patrol. The length of a patrol box side is entered as a number of five minute turns.

3 Operational Turns

The use of operational turns is a option specified by the scenario file. If used, forces will move based on waypoints or patrol areas. Forces follow the programmed courses using five minute turns until contact is made with any enemy force. Since only the locations of the force guides are calculated and no combat routines are used, this code is relatively fast. The primary purpose of operational turns is to provide for some variation in the initial positions for the tactical game.

If operational turns are not specified, the game starts with the ships disposed based on the scenario file and tactical turns may begin.

3.1 Detection

Operational turns will be interrupted if any force is in detection range of an enemy force. The detection range is a function of visibility and force size. Once any force is detected, all forces will be disposed and tactical turns may begin.

3.2 Disposition

Ships of each force are placed relative to the current force guide position and course based on their relative positions in the initial load of the scenario file. Optionally, the code AI can create force dispositions for an AI controlled side.

4 Tactical Turns

More than one turn may be run without interruption, or with selected interruption events, but this feature is generally used only for testing. In an actual game, the players will receive reports and may issue orders after each five minute turn. AI controlled forces will issue orders at the end of each five minute turn.

4.1 Player Inputs

Prior to running each turn, changes may be made to:

courses, speeds and formations
gun and torpedo targeting and firing modes
smoke generation
stations

4.2 Turn Sequence

Each turn is divided into five one minute impulses. Prior to the first impulse, variable wind and visibility values are updated, and values from the previous turn required for dynamic algorithms are read from spreadsheet cells.

The following sections describe the operations performed in each impulse.

4.2.1 Smoke

The amount of smoke generated by each ship is calculated from:

current speed, speed made good, speed change
coal/oil burning characteristics of boilers
coal quality
intentional funnel smoke generation
chemical smoke generation

4.2.2 Visible Ships

For each ship not previously visible it is determined if it or its smoke is visible from an enemy ship. Sighting reports are generated.

4.2.3 Targeting

Unless targets are manually selected by the players, current targets are evaluated and new targets are selected based on range, type, ammunition, fire priorities, obstructions and concentration. Obstructions are a function of wind direction and strength, range, bearing, smoke and fire control type.

4.2.4 Firing

For each ship, the following are determined:

sea state adjusted fire control efficiency based on class, battery and sea state

concentration adjustments based on shell weights, shells fired
propellant remaining in each magazine (for damage calculations)
low ammunition alarm flags
number of guns firing and relative bearings
shell type (AP/HE) fired based on doctrine, input selection and availability
hit probability as a function of:
- range
- fire control and range finder type
- concentration
- change of target
- downwind, upwind, obstructions, sun glare
- firing ship and target ship speeds and course changes
- target size
- incoming fire
- previous impulse rapid fire
- visibility
- target angle
- trunnion tilt
- roll for angle of firing ship to sea
- range rate

rate of fire as a function of
- previous damage
- downwind, upwind, obstructions, sun glare
- incoming fire
- firing ship maneuvers
- time of flight

rapid fire as a function of hit probability and rate of fire
open fire reports
number of hits

4.2.5 Damage

If hits are obtained, the following damage routines are performed:

scaling adjustments for thick cemented armor
scaling adjustments for Harvey vs Krupp cemented armor
adjusted magazine explosion probability based on overloading
random variation in shell handling faults (once per ship)
angle of fall
underwater belt hit height based on angle of fall
target angle
deck hit probabilities based on target angle and angle of fall
turret roof and barbette hit probabilities based on angle of fall
funnel hit probabilities
turret face incline adjustments
AP shell shatter probabilities based on armor type, AP cap type and incidence angles:
- lower belt abreast magazine
- lower belt abreast machinery
- middle belt
- upper belt
- forward belt
- aft belt

projectile kinetic energy

For each hit:
- random adjustment to penetration

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horizontal and vertical penetration (direction refers to shell travel)
premature shell explosion due to sensitivity
hit location (adjusted for angle of fall, target angle)

For aft hits:
- side or deck

  For aft deck:
  - vertical penetration

  For aft side:
  - unarmored side or belt

    For unarmored side:
    - horizontal penetration

    For belt:
    - shell breakup
    - adjusted horizontal penetration
    - dud or low order detonation, shatter, spalling

  - delay fuse action
  - steering damage
  - stern or aft torpedo room damage

For forward hits:
- side or deck

  For forward deck:
  - vertical penetration

  For forward side:
  - unarmored side or belt

    For unarmored side:
    - horizontal penetration

    For belt:
    - shell breakup
    - adjusted horizontal penetration

  - dud or low order detonation, shatter, spalling
  - bow or forward torpedo room damage

For gun hits:
- primary, secondary or tertiary battery based on class data
- roof or face

  For roof:
  - vertical penetration adjusted for roof slope
  - dud or low order detonation, spalling

  For face:
  - adjustment for curved or faceted face, face slope
  - AP shell shatter probability
  - horizontal penetration

  - dud or low order detonation, shatter, spalling
  - gun losses
  - turret and magazine fires and explosions

For barbette hits:
- adjustment for barbette curve

AP shell shatter probability
horizontal penetration
dud or low order detonation, shatter, spalling
gun losses
turret and magazine fires and explosions

For superstructure hits:
adjustment for conning tower curve
AP shell shatter probability
horizontal penetration
dud or low order detonation, shatter, spalling
steering casualty
fire control damage based on fire control type
wireless telegraphy damage

For citadel hits:
side or deck

For citadel deck:
upper deck penetration
dud or low order detonation, spalling
delay fuse action
magazine or machinery damage
deck mounted torpedo tube damage

For citadel side:
upper, middle or lower belt
below waterline
deck slope behind belt
AP shell shatter probability
horizontal penetration
dud or low order detonation, shatter, spalling
delay fuse action
magazine or machinery damage

For funnel hits:
funnel damage
boiler damage

General damage
flotation losses due to:
flooded magazines
flooded torpedo rooms
other hits

Damage reports

4.2.6 Ammunition Expenditure

Remaining ammunition is determined.

4.2.7 Collisions

Collisions between enemy ships are based on projected courses, speeds, steering capability and ship sizes. Damage is based on speed, size, ram or bow type and location. Damage may include flotation loss, magazines, machinery damage and torpedo room flooding.

Collisions between friendly ships are a code option and not generally used.

4.2.8 Retreats

New courses are determined for ships:
- avoiding collisions
- retreating from enemy fire based on selected doctrines for each ship type

4.2.9 Torpedo Fire

Torpedo fire is performed based on targeting, visibility to target, projected target intercept, torpedo speed and range, potential friendly ships in the torpedo path and target maneuvers. Firing solutions are calculated using standard naval trigonometry from target angle, target speed, torpedo speed and torpedo range.

The number of torpedoes launched is based on number and location of tubes, relative bearing of torpedo course, speed limitations and doctrine. Torpedoes may fail on launch due to speed limitations on underwater tubes. Data for each launch is saved to the spreadsheet for use in future impulses.

Visibility of torpedo launches is based on visibility, range and launcher type. Visible launch reports are generated.

4.2.10 Formation and Station Courses

Course and speed is determined for ships:
- using waypoints
- taking stations
- moving to disengaged sides of station guides

New station guides are selected if required.

4.2.11 Torpedo Resolution

Torpedo positions and spread are based on course, speed, time since launch and numbers launched. The areas covered by the spread are compared with all ships positions. For potential targets the visibility of the torpedo tracks is based on sea state, torpedo nationality, visibility and target efficiency. Evasion probability is based on torpedo visibility, relative bearing, speeds, and target type. Evasion courses are toward or away based on relative bearing. Torpedoes may fail to hit due to control loss at higer seastates. For hits, duds are based on torpedo nationality and date.

Damage may include flotation loss, magazines, machinery, shafts, rudders or torpedo rooms. Damage is based on class underwater protection and torpedo warhead (weight and explosive type).

4.2.12 Minefields

Ship positions are compared with minefield areas. Mine avoidance is based on mine density, speed, ship cross-sectional area and sea state. Mines may be hit or reported. For hits, duds are based on mine nationality and date.

Damage may include flotation loss, magazines, machinery damage and torpedo room flooding. Damage is based on class underwater protection.

4.2.13 Shoals

Ship positions are compared with shoal areas. Grounding is based on speed, shoal depth and current ship draft.

Damage may include flotation loss and permanent grounding.

4.2.14 Movement

Lead ship positions are updated based on course, speed, acceleration and deceleration. Speed reductions for turns and sea state are calculated. Course and speed is determined for ships with steering casualties. Non-lead ship positions are updated based on formation, required position in formation, available speed and current position. Speed made good is calculated.

Chemical smoke locations are updated based on wind and ship positions.

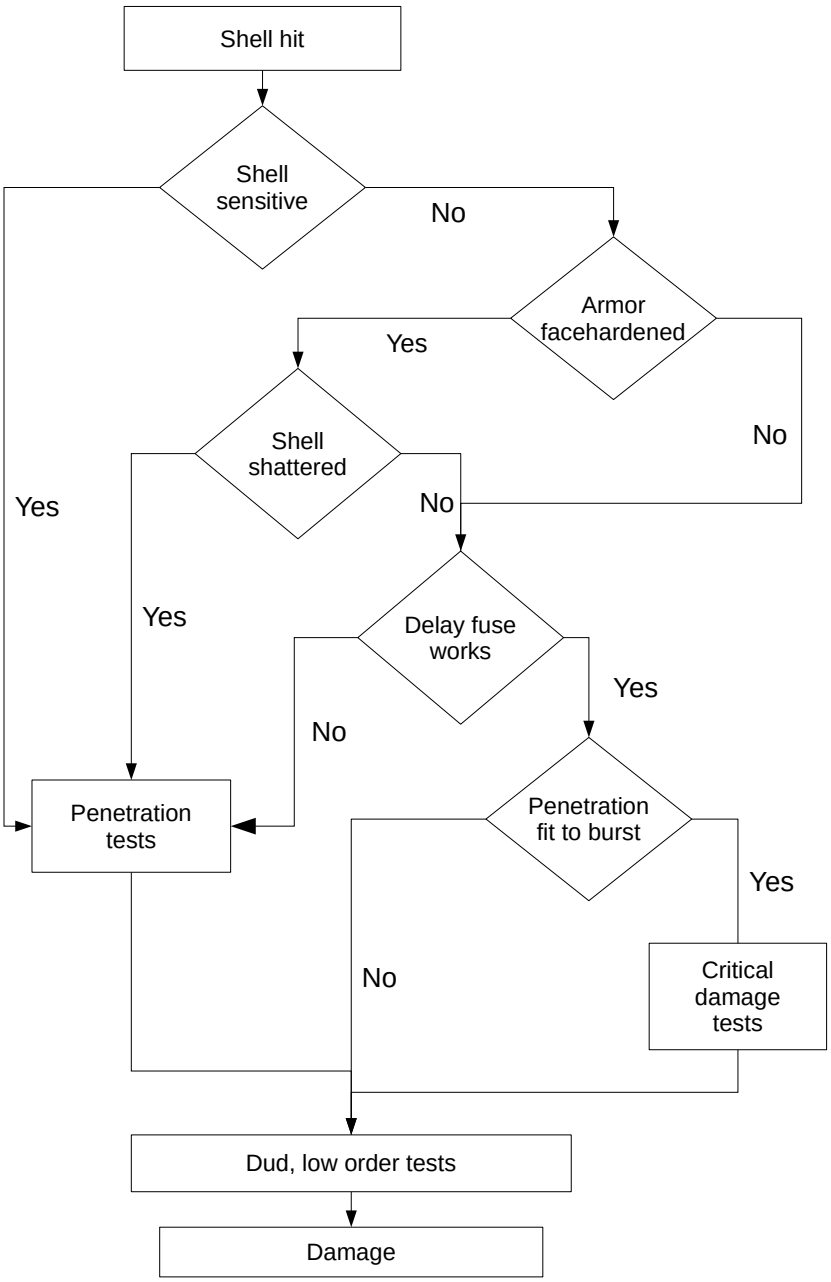
4.2.15 Data Update

Data from the one minute impulse is written to the spreadsheet. Plot data is written to the plot file.

4.3 Turn Reports

Reports of turn events, targeting, positions and hits are written to the force output files.

5 Figures



Shell Failure Flowchart

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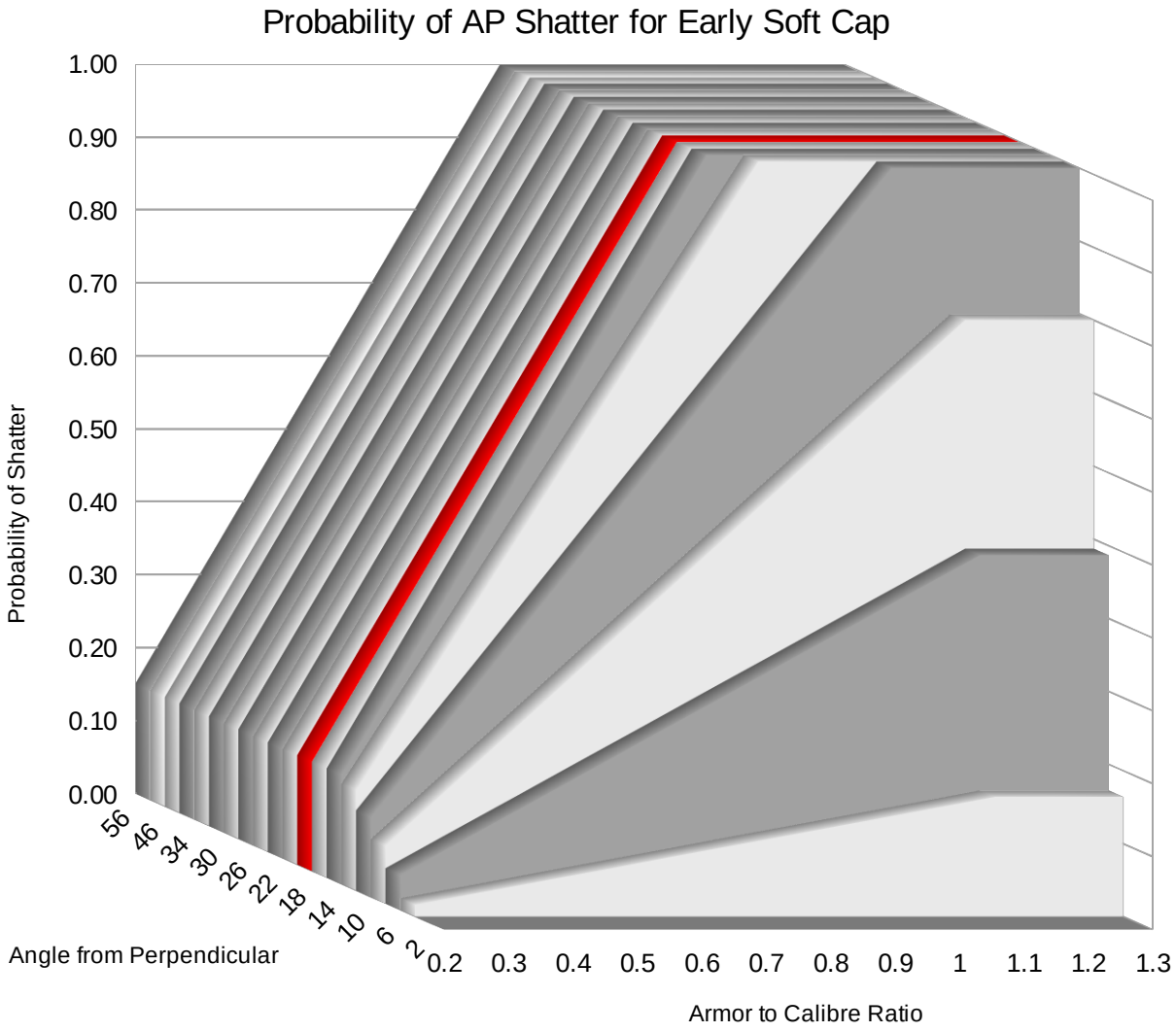

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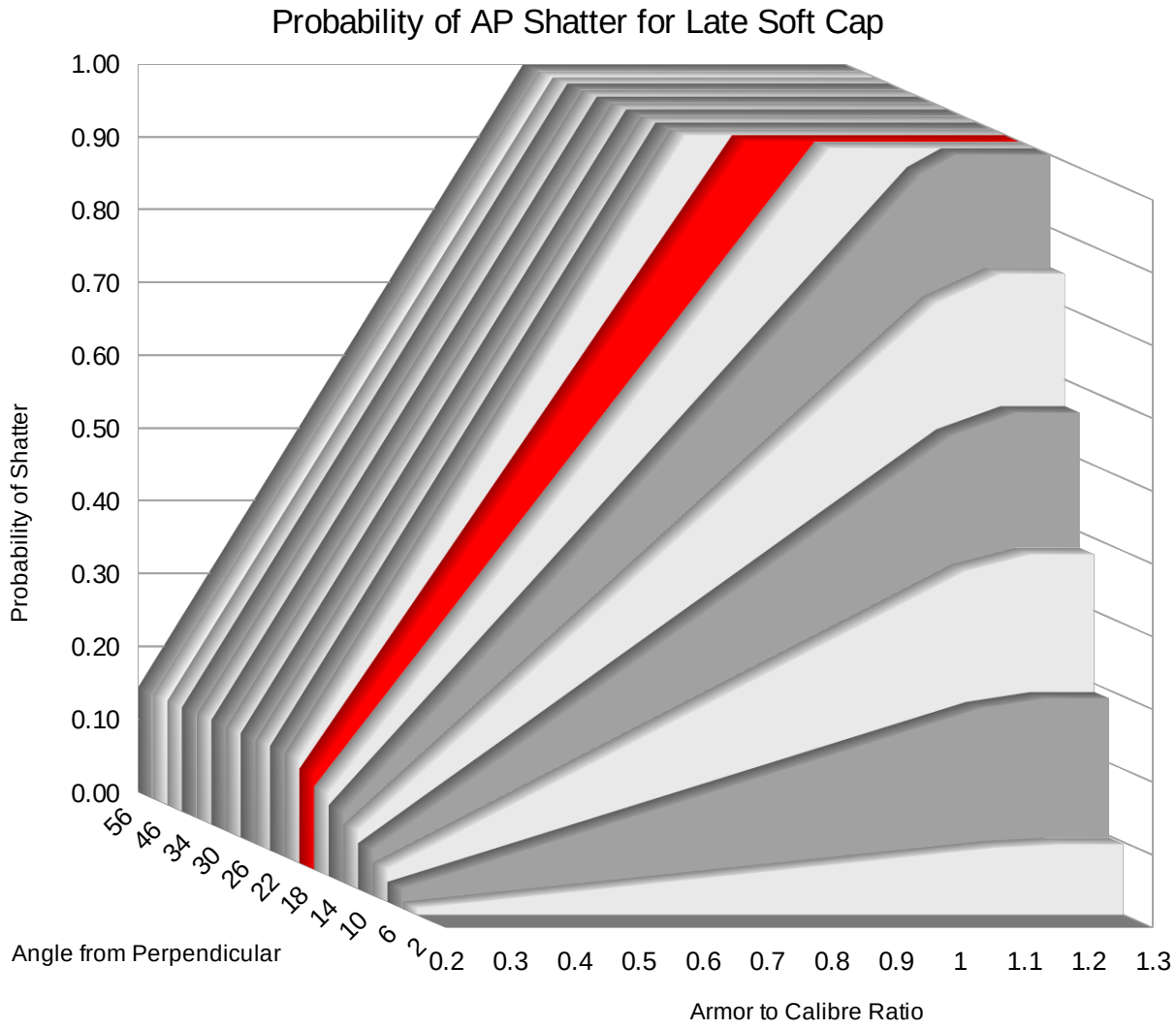

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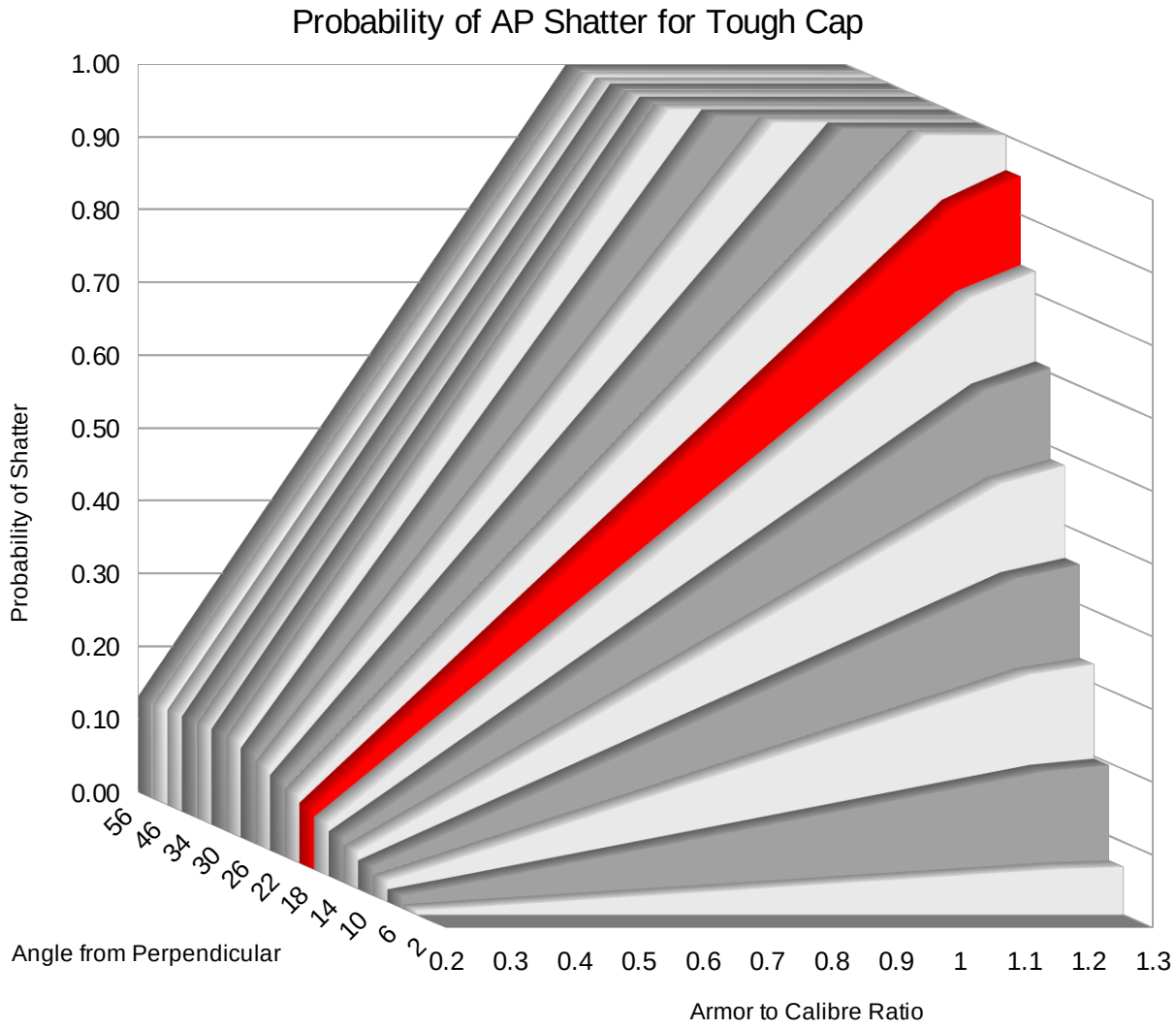

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