Weapons Effects and Warship Vulnerability

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Admiralty Trilogy Seminar

Presented by:

Clash of Arms Games

Outline

- *Admiralty Trilogy* Harmonization Project
- Damage Mechanisms
- Weapons Effects Modeling
- Underwater Damage
- Above Water Damage
- Examples
- Ship Damage Capacity
- Conclusions

AT Harmonization Process

- During the development of *Fear God & Dread Nought* and *Dawn of the Rising Sun* modeling differences were noted with *Command at Sea*
- Modeling differences had an unforeseen impact on system continuity and would significantly affect products that spanned the timeframe between games
  - Biplanes & Battleships (*FG&DN – CaS*)
  - Stars & Stripes (*CaS – Harpoon*^{4})
- Harmonization is the process to bring all game mechanics and system modeling into conformity with each other
- Weapon damage effects on ships is one of the biggest issues in the Harmonization Process

AT Harmonization Process

- **Weapons damage effects**
  - **Back to first principles - physics**
  - **Fundamental approach focusing on how explosives work**
- **Develop a consistent basis to evaluate weapons**
  - **Smaller set of modeling equations that would apply to all weapons**
  - **Take into account technological advances (explosives, fuzing)**
- **Develop an improved way to define ship damage capacity**
  - **Smooth out the damage point step function to a continuous curve**
  - **Better define construction and material modifiers**
- **Correct current model distortions (edge effects) to provide a smooth transition between major period games**

Weapon Damage Mechanisms

- **Explosives – Basis for damage mechanisms**
  - **Rapid conversion of chemical potential energy into heat, smoke, noise and kinetic effects**
- **Blast Effects**
  - **Formation of a shock or high pressure wave**
- **Fragmentation Effects**
  - **Breakup and acceleration of case material**
- **Incendiary Effects**
  - **Generates a lot of heat**

Weapons Effects Modeling

- Blast and fragmentation account for the vast majority of damage causing effects
  - Incendiary effects rolled into critical hits
- Convert blast and fragmentation effects into energy terms
  - Blast Energy: Based on explosive loading and explosive type
  - Fragmentation Kinetic Energy: Based on ordnance type, explosive loading and explosive type
- Use warhead weight$^{1/3}$ equation for blast and fragmentation effects
- Use warhead weight$^{1/2}$ equation for underwater shock

Underwater Damage Effects

- **Fuzing is a significant issue**
  - **Determines damage equation**
  - **Influence fuzing far more deadly**
- **Contact Fuze**
  - **Uses Warhead $Wt^{1/3}$ equation**
  - **Damage Point conversion factor based on historical analysis**
    - **1 – 2 hits to sink a DD**
    - **2 – 3 hits to sink a CL**
    - **3 – 4 hits to sink a CA**

***USS Tripoli* contact mine damage**

Damage Points = $12.1 \times (WxTE)^{1/3}$

W = Warhead weight (kg)

TE = TNT Equivalence

Underwater Damage Effects

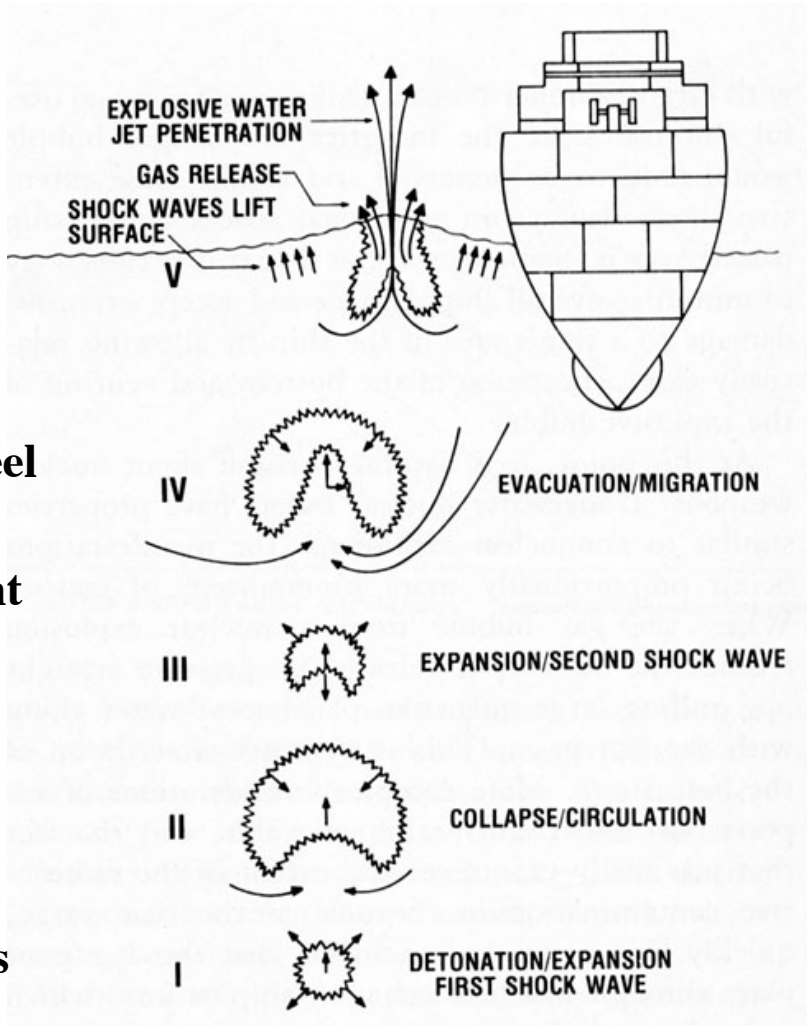
- **Influence Fuze**
  - Uses Warhead $Wt^{1/2}$ equation
  - Damage Point conversion factor based on sinkex analysis
    - 8,000 ton ship limit on breaking keel in two
    - Assume 75% massive damage point

Damage Points = 7.6 x $(WxTE)^{1/2}$

W = Warhead weight (kg)

TE = TNT Equivalence

Halve the weight for attacks against subs



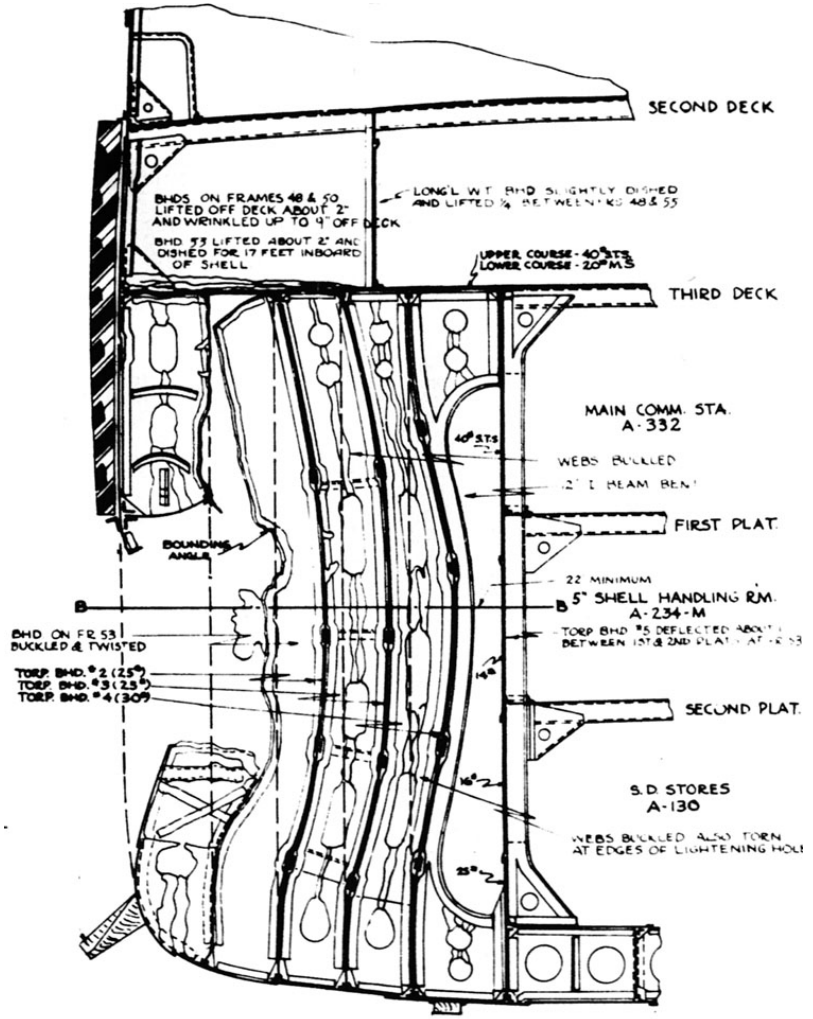
Underwater Contact Damage

- **Type 91 Mod 1**
  - **150 kg, Type 97**
  - **TNT Equiv = 0.98**

DP = 12.1 x (150 x 0.98)$^{1/3}$

New Damage = 64 DP

***CaS* damage = 38 DP**



***USS California* Pearl Harbor damage**

Underwater Influence Damage

- **Mk48 Mod 4**
  - **300 kg, PBXN-105**
  - **TNT Equiv = 1.80**

DP = 7.6 x (300 x 1.80)$^{1/2}$

New Damage = 177 DP

H^4 damage = 150 DP

***HMAS Torrens* MK48 Torpex**

Above Water Damage Effects

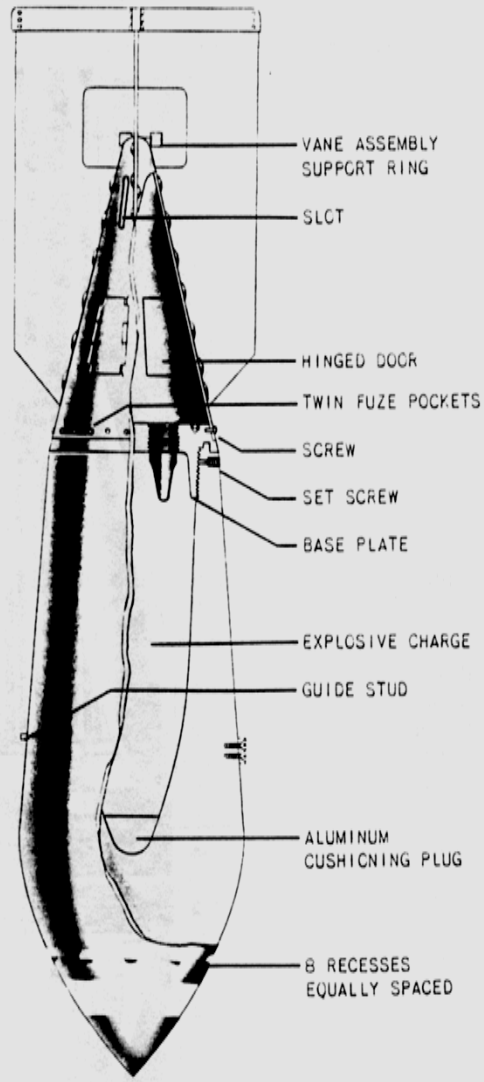
- **Single equation for bombs, missiles and shells**
  - **Convert all damage mechanisms into energy terms**
  - **Uses Warhead $Wt^{1/3}$ equation**
  - **Damage Point conversion factor based on historical analysis**
    - **Bombs: 0.503**
    - **Shells: 0.495**
    - **Assume 0.50 for all weapons**

$\text{Damage Points} = 0.5 \times [(\text{Blast Energy})+(\text{Frag KE})+(\text{Residual Mass KE})]^{1/3}$

- **Blast energy = chemical energy from detonating explosive**
- **Fragment KE = energy from the breaking up of warhead case**
- **Residual mass KE = energy from the impact of residual missile after detonation**
- **Bombs and Shells only have blast and frag KE**
- **Missiles have residual mass KE as well as blast and frag KE**

Bomb Damage

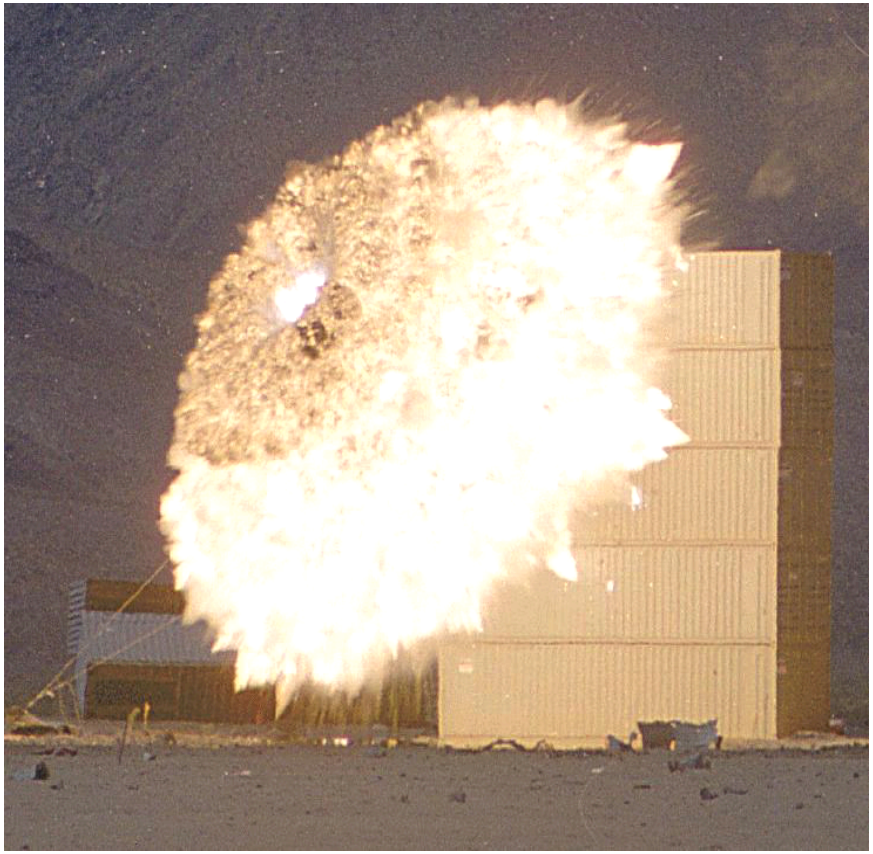
- **Bomb Damage**
  - **Blast Energy**
    - **Explosive loading**
    - **Explosive Type (TNT equivalence)**
    - **TNT Q = 4,132 kJ/kg**
    - **60% of energy goes into blast**
  - **Fragmentation Kinetic Energy**
    - **Fragmentation mass**
    - **Velocity of fragments**
    - **Gurney equation**
  - **No Residual Mass Kinetic Energy**
- **Type 99 No 80 Mk 5**
  - **New damage = 27 DP**
  - ***CaS* damage = 7 DP**



Type 99 No. 80 Mk 5 Bomb.

Shell Damage

- **Shell Damage**
  - **Blast Energy same as bombs**
    - **Much lower explosive loading**
  - **Fragment Kinetic Energy same as bombs**
    - **Fragment velocity also has residual velocity component after armor penetration**
  - **No Residual Mass Kinetic Energy**
- **15in Mk I APC**
  - **New damage = 36 DP**
  - ***FG&DN* damage = 40 DP**



Shell Damage

- Gun rate of fire also effects gunnery damage
- Rate of hit often assumed to be linearly proportional to rate of fire
  - Review of UK gun layer exercises does not support this assumption (Brassey's Naval Annuals)
  - Limited US data also not supportive
- Each gun system rate of hit will use a uniform set of equations that are based on maximum rate of fire
  - One equation for each range band
  - Equations are no longer linear (power function)
  - Fewer hits at high rates of fire due to increase in mount dispersion error

Missile Damage

- **Missile Damage**
  - **Blast Energy same as bombs**
  - **Fragment Kinetic Energy same as bombs**
  - **Residual Mass Kinetic Energy based on 33% of missile launch weight**
- **Harpoon missile**
  - **New damage = 40 DP**
  - **H^4 damage = 45 DP**

***USS Buchanan* Sinkex**

Examples: Torpedoes

Torpedo	Explosive	Warhead Weight (kg)	New DPs	Old DPs
Mk14	TNT	292	80	73
Mk14	Torpex	292	91	110
Type 93 Mod 1	Type 97	490	95	125
A-184	H-6	150	108	75
Mk48 Mods	PBXN-105	300	177	150
65-76	TGAG-5	500	197	250

Examples: Bombs

Bomb	Weight (kg)	Weight Filler (kg)	New DPs	Old DPs
Mk57A1 GP	118	59	30	12
Mk64A1 GP	238	121	38	33
M65A1 GP	449	253	48	70
M59A1 SAP	451	145	43	48
Mk1 AP	721	98	39	33
M66A1 GP	956	507	60	84

Examples: Shells

Shell Size & Type	Weight (kg)	Weight Filler (kg)	New DPs	Old DPs
12in APC	386.8	9.7	28	19
13.5 in APC	567.2	14.2	32	27
15 in APC	870.9	21.8	36	40
15 in HE	870.9	87.1	50	69

Examples: Missiles

Missile	Weight (kg)	Warhead Weight (kg)	New DPs	Old DPs
Harpoon 1C	520	221	40	45
P-700 Granit [SS-N-19]	7,000	750	70	125

Note: Explosive loading is 45% of warhead total weight

Ship Damage Capacity

- **Consolidation of the four damage point equations into one continuous function**
  - **Smoothes out the discontinuities between each step**
  - **Most ships gain some damage capacity, particularly small ships**
  - **Above 300 tons, maximum change in damage points is about 10%**
  - **Better definitions of construction and material modifiers**
  - **Greater displacement without bulging results in lower damage capacity**

Conclusion

- **Weapon damage effects across the *Admiralty Trilogy* games are now consistent with basic physical principles**
  - **Convert all damage mechanisms into energy terms**
  - **Use standard explosive theory equations**
  - **Eliminates model distortions (edge effects)**
- **Damage point value changes vary based on weapon type and warhead size**
  - **Torpedoes have the greatest change**
  - **Less so for bombs, shells and missiles**
  - **Smaller warheads become more lethal, very large ones are less**
- **Single ship damage capacity equation eliminates the jumps between the displacement steps of the present system**

Questions?