Background Data: Strategic Air Offensive vs. Germany
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U.S. vs. British Viewpoints

- Goal: "destruction and dislocation of the Germany military, industrial, and economic system and the undermining of the morale of the German people to the point where their capacity for armed resistance is fatally weakened"
  - U.S.: Accurate (daylight) bombing of strategic industries and services to disable Germany's war economy
  - Britain: City area (night) attacks to undermine the German people's will to fight

Questions for Discussion: Allied Offense

- What to bomb, and what is it worth?
- Military technology - what is the most effective kind of bomb?
- How to find targets?
- How to get home safely?
- In retrospect, what was effective?

Strategic Targets

- Target Type
  - Military
  - Transportation
  - Industrial
  - Petrochemicals
  - Others?
- Strategic Air Offensive
  - US 8th Air Force
    - 333,000 sorties
    - 15,000 losses (4.6% loss rate)
    - 622,000 tons of bombs
  - Britain Bomber Command
    - 374,000 sorties
    - 10,000 losses (2.7% loss rate)
    - 955,000 tons of bombs
**Round 1: Target Planning**

- RAF: Area/City Bombing
- USAAF: Precision Strategic Bombing

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**German Radio Navigation**

**Knickebein**

![Knickebein map](image)

*Fig. 9.1 Knickebein Germany’s first navigational and targeting system*

**German Radio Navigation**

**Y-Gerät**

![Y-Gerät map](image)

*Fig. 9.3 Y-Gerät Y-Gerät attempted high precision by combining Norden's geodetic network with a new radio navigation system with a 3,000-mile unobstructed range. The range was increased by a factor of 10 by a Beidenbender to be used in conjunction with Norden’s geodetic network, resulting in a total range of 30,000 miles. Unfortunately, the equipment was not ready by the time the battle ended.*

**British Counter Measures**

- Jamming
- Beam Bending
Radio Navigation
British Approach—Gee

- 3 xmitters: Master, A, B
  - START: Master emits pulse
  - 1 ms: Slave A emits pulse
  - 2 ms: Master emits double sync pulse
  - 3 ms: Slave B emits pulse
  - Repeats every 4 ms/250 per s
- Difference in time between master and slaves defines a unique point where two hyperbolas intersect
- Limited precision because of difficulty in syncing slaves with master

Radio Navigation: British Approach—Oboe

- Many stations placed around England
- Any can be Cat or Mouse
- Very accurate 110m @ 400km
- Used by Pathfinders to mark targets

Formation Defense
MGs and Mutual Support

Formation Defense

Video Interlude
- Bomber Tactics
Bomb Effects
Cologne After 1000 bomber raid 1942

Bomb Effects
Dortmund 1945

Bomb Effects
Hamburg, after a shattering assault in 1943:
40,000 dead and 70% of the city destroyed

Bomb Effects
Peenemünde before and after concentrated attack, 1943.
44 aircraft lost. The first V2 fell on London in 1944.

Bomb Effects
Phillips factory, Eindhoven, 1942, attacked by 93 aircraft.
148 civilians killed, production stopped for 6 months

Bomb Effects
Mohne dam after raid by highly trained crews, at night.
8 of 18 planes failed to return.
Bomb Effects

Lancaster and Grand Slam Bomb (22,000 lbs.)

Challenge of Precision Bombing

Le Havre, 1944

Challenge of Precision Bombing

Emmerich, 1943

Paulliac, 1944, target markers have just been released

Paulliac, 1944, 5 minutes later
Target indicators bursting over Frankfurt, 1944, laid by Pathfinders.

Night Photography
Fires and Searchlights Ruin Photos

NIGHT PHOTOGRAPHY WITH BOMBING

Ground Radar
H2S view of the Zuider Zee dam

Ground Radar
Map and H2S view of Oslo Fjord, 1943, during an anti-shipping strike.
Bomber Vulnerability
Heavy bomber hit by flak at 45000 feet

Round 2: Allied Technology Development

Questions for Discussion:
German Defense
• How to make bombing more expensive
  - by destroying bombers
  - by leading bombers off target
• How to detect incoming raids?
• How to coordinate response to incoming raids?
• How to engage bombers at night?

German Radars
• Higher frequencies/shorter wavelengths than comparable British radars
• Ability to tilt and rotate
• For coast and inland defense
• 100 km range at 10,000 feet

German Radars
• Wurzburg tracking radars
  - Elevation and azimuth easily positioned
  - 25 km range

German Night Fighter
Airborne Radar
Night Fighter Defense

- No effective night escorts until late in the war
- Surface radars & human controllers vector night fighters to bombers
- Bombers illuminated by searchlights makes them visible
- Nightfighters attack from below and behind, very difficult to see
- Affects the targets in the end: destroy the German air force!

Round 3: German Response

Defensive Technologies and Response

- Searchlights
- AA Guns
- Proximity Fuze
- Airborne Radars for interception
- Fly high
- Window/Chaff
- Window/Chaff

Offensive Technologies and Response

- Longer range, heavier bombers
- Longer range escorts with drop tanks
- Surface radars for night target identification
- Gyrostabilized bomb sights
- Guided bombs
- Better interceptors (Jet and Rocket Fighters)
- Jamming
- Distribute production

Measure-Counter Measure-Counter-Counter Measure

- "The atom bomb ended the war, but radar won it."
- Radar-Jamming-Higher Frequency or Frequency Agile Radar
- Radar-Window-Doppler Radar that discriminates between slow moving strips of metal and airplanes
- Beam Radio Navigation-Jamming or Beam Bending-Alternative Non-Beam Navigation Approaches

U.S. Strategic Bombing Survey


- "The city attacks of the RAF prior to the autumn of 1944, did not substantially affect the course of German war production. German war production as a whole continued to increase."
- "The city area raids have left their mark on the German people. Far more than any other military action... these attacks left the German people with a solid lesson in the disadvantages of war. It was a terrible lesson, conceivably that lesson, both in Germany and abroad, could be the most lasting single effect of the air war."
- "Conventionally the air forces designated as 'the target area' a circle having a radius of 1000 feet around the aiming point of attack. While accuracy improved during the war, Survey studies show that, in the over-all, only about 20% of the bombs aimed at precision targets fell within this target area."

- Schweinfurt Raids: Massed attacks against ball-bearing plants successfully and dramatically reduced production but at unsustainable cost in crew losses (long range penetration without benefit of fighter escort—formation flying didn't work)

- Loss of planes vs. loss of pilots

### German Aircraft Production

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