Background Data:
Naval Warfare,
Battle of the Atlantic,
Cryptography, and the Code Game

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Battle of the Atlantic
Allied Convoys vs. German U-Boats

• Germans on the Offensive, Allies on the Defensive
  - Choosing Targets
  - Assembling Forces
  - Finding the Enemy
  - Attacking with Precision or Causing As Much Damage as Possible
  - Avoiding/Surviving Defenders
  - Determining the Effects of Naval Combat
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Battle of the Atlantic: Merchant shipping losses (quarterly), number of U-boats operational in the Atlantic (Frontboote), and U-boat losses, 1939–45

Merchant Shipping Losses (100,000 tons)

Number of Frontboote

U-boat losses


6. Battle of the Atlantic: U-boat dispositions, 1 May 1943
Convoys
“Das Boot”
Naval Intelligence
Finding the Enemy, Hiding Your Forces

• Is an "unbreakable" code possible?
• Is it possible to "hide" coded transmissions?
• How do you balance the need to communicate with the need to be invisible to easedropping?

• Cryptography, Cryptanalysis
  - Heroic Codebreaking: Enigma, the Battle of the Atlantic, and the Development of the Computer
  - Codebreaking in the Pacific: Intelligence successes at Midway

• Technology and the Battle of the Atlantic
  - Airborne Radars, High Frequency Direction Finding
Signals Intelligence

• Collecting information about a (potential) foe's capabilities (economic, military) and intentions (political, military) as old as nations themselves!

• New about the late 19th and 20th Centuries:
  - Rise of far-flung empires, increasing use of technologies for communications, need for command and control
Development of Communications Technology

- Commercial = Militarily Relevant Technologies
  - Electric Telegraph (1837)
  - Undersea Cables (1842); transatlantic cable (1866)
  - Transcontinental Telegraph (1861); crucial role in American Civil War
    - Marconi, Radio (1895): first customer--the Royal Navy!
- Counter measures: cut foe's undersea cables, message interception, message deception;
- Counter counter measure: radio communications
- Counter counter counter measure: jamming, direction finding
- Every measure has a counter measure, and in turn, a counter-counter measure!
To Communicate is to Reveal

- Communication methods lead to detection
  - Can the detector be detected? identified as to individual and location?
  - Can the interceptor be fooled? traffic analysis and deception?
  - Can the communicator be stopped from successfully communicating? jamming?
  - Can the communicator hide his/her communications? stealth?
Intelligence Collection

- Spying, reconnaissance, spy satellites, code breaking
- Human intelligence (HUMINT) aka spies
- Signal intelligence (SIGINT)/Communications intelligence (COMINT) often used interchangeable, especially up through WWII
  - Modern militaries use many forms of electromagnetic radiation that don't involve communications, but are used for detection (e.g., RADAR)
  - Information derived from the monitoring, interception, decryption and evaluation of enemy radio communications
  - Naval intelligence particularly important, as until the development of recon satellites, the ability to put "eyes" at sea was very limited!
Codebreaking

• Before the Age of Radio, much more difficult to intercept cable traffic
• Radio potentially places large numbers of encrypted messages in the hands of the cryptanalysts
  - Key to breaking the code!
  - British Admiralty Room 40: Codebreaking Room
Enigma Machine

• Existence of ULTRA ("Very Special Intelligence") first revealed in 1974! Changed completely the way we view the history of WW II

• Combined encoding/decoding machine
  - Five rotor system, three in use at any time
  - How it worked and why it was hard to crack
    • Use of per message keys makes analysis difficult
    • But patterns provide the way in: doubly encrypted message keys
    • Poles reverse engineer a stolen Enigma machine
    • Invention of the Bombe: mechanical device to exhaust all enumerations
    • New Enigma stumps the Poles who turn to the British (1939)
Guessing the day key: cillies—common three letter sequences
Human operator weakness!
Rules of usage also limit the alternatives
Stereotypical message structure helps too
Turing’s idea: the crib—<common plain text, encrypted text>
If found, then could determine Enigma settings
Compute the transformation in parallel: Turing’s Bombe
10 May 40: Germans change their message key scheme
Naval codes hardest to break—more sophisticated Enigma used
Battle of Atlantic was being lost! Solution: pinch the codebooks!
“Enigma”
Enigma Deciphered

reflector RB  Rotor III  Rotor IV  Rotor I  plugboard  keyboard
The Bombe

Colossus
The Code Game

% Letter Occurrence in English Text

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The Code Game
More Text Analysis

• **Common Digrams:**
  - th he at st an in ea nd
    er en re nt to es on ed
    is ti

• **Common Trigrams:**
  - the and tha hat ent ion
    for tio has edt tis ers
    res ter con ing men tho

• **Double Letters:**
  - ll tt ss ee pp oo rr ff cc
dd nn

• **Common word ending letters:**
  - e t s d n r y

• **Most common words:**
  - the of are I and you a
can to he her that in
  was is is has it him his