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

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 eavesdropping?
- 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)

Bletchley Park

- 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

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
    en re nt to es an ed is ti

- Common Trigrams:
  - the and the hat ent ion
    for tie has ed t tie ers
    re ter can 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 has it him his