FOR ELITE CRACKERS ONLY

British National Cipher Challenge 2020 Special Edition
ELITE Cipher Challenge
Three Solutions by madness

Finding the ELITE challenge

The address of the ELITE challenge is hidden in the plaintext of the 9B challenge (see the Appendix for the ciphertext and plaintext). 9B was encrypted with different Caesar shift for each word. To make things easier, the words were separated by a slash when the ciphertext was encoded with Morse code. This short block of Python code decrypts it quickly:

```
alphabet = "ABCDEFGHIJKLMNOPQRSTUVWXYZ"

morse = ['.-', '-...', '-.-.', '-..', '.', '..-.', '--.', '....',
         '..', '.---', '-.-', '.-..', '--', '-.', '---', '.--.',
         '--.-', '.-.','...', '-', '..-', '...-', '.--', '-..-',
         '-.--', '--..']

ciphertext = ciphertext.split(' ')
plaintext = ""
shift = 1
for x in ciphertext:
    if x == "/":
        shift += 1
        plaintext += " "
    else:
        plaintext += alphabet[(morse.index(x) - shift) % 26]
```

The first letter of each sentence of the plaintext gives us the location of the ELITE cipher. Luckily, 9B is a telegram, so there is no doubt about the boundaries of the sentences (they end in "stop"). We get

www dot cipher challenge dot org slash elite

or,

www.cipherchallenge.org/elite

Notation

I will be using the convention that plaintexts are written in monospaced lower-case letters, while ciphertexts will be written in upper-case letters. When it is important to explicitly show that a space is present, I will use the underscore ("_"). Also, I will use ">" and "<" to mean "is encrypted as" and "decrypts to", so that "x > Y" or "Y < x" means that when we encrypt x we get Y, and when we decrypt Y we get x.

Initial examination of the challenge

We are greeted with this introduction:

> You have joined an elite band of cryptanalysts who have cracked the final round of a BOSS training mission. Or have you? Clearly the story can't end there, and if you want to read the final instalment before everyone else gets to, then you will have to crack one final code. You solved part of the puzzle by finding this page. Now you have to use all your skill to break the cipher protecting the attached report from Swallow, which details the final adventure. It is like nothing you have seen before in this edition of the competition, but I will tell you that it is inspired by the simple combination lock!

Try to remember that bit about the combination lock.

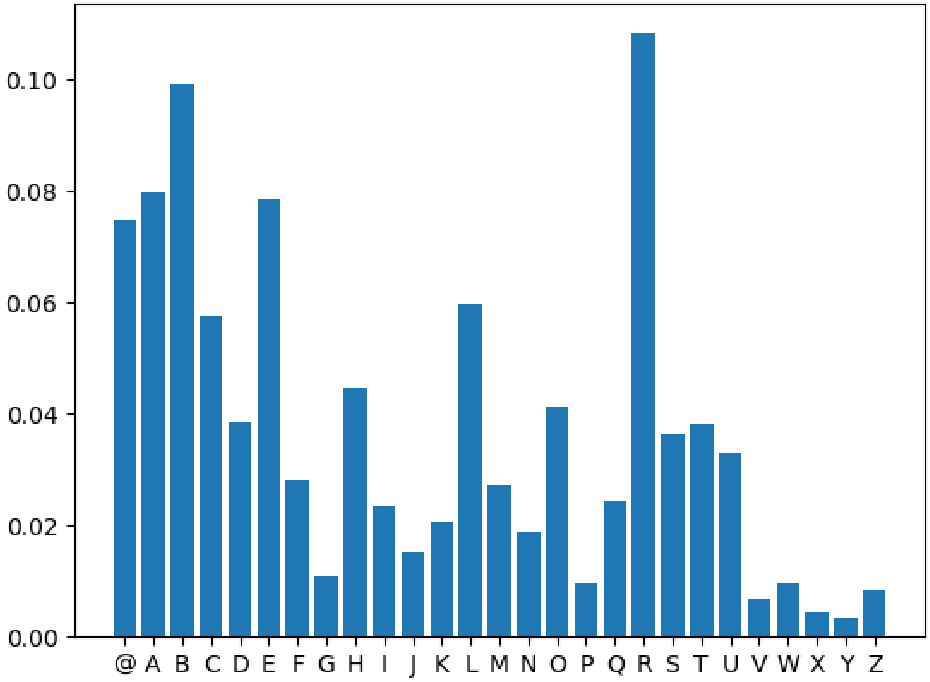
The ciphertext follows; a full copy of it is in the Appendix. Notice that its character set is

```
@ABCDEFGHIJKLMNOPQRSTUVWXYZ
```

It is reasonable to think that the addition of the "@" character means that spaces in the plaintext have been included in the encryption. So the character set of the plaintext will be

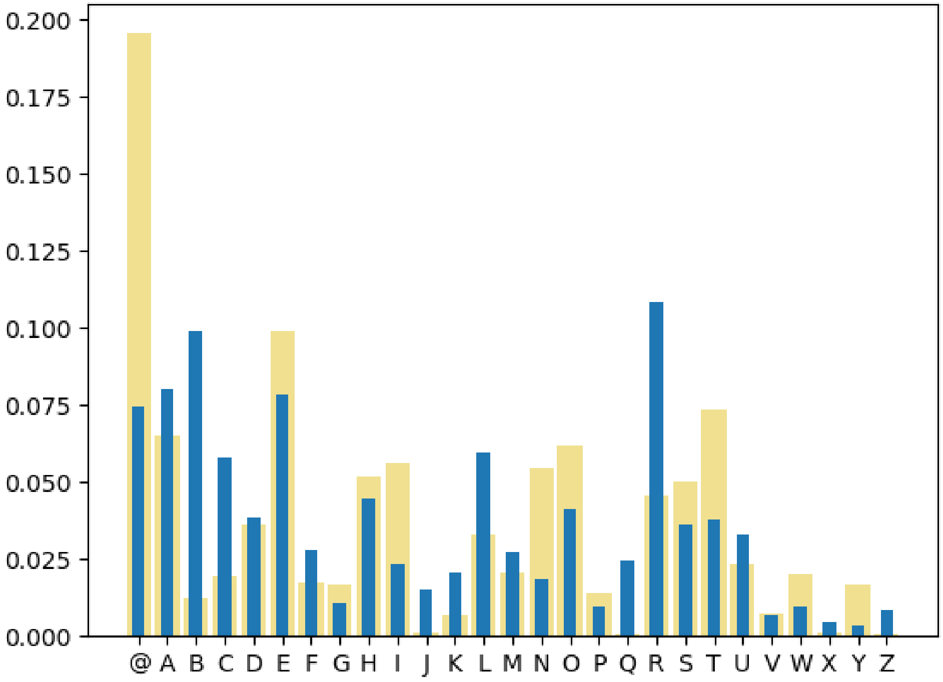
```
_abcdefghijklmnopqrstuvwxyz
```

If we look at the frequencies of the characters in the ciphertext, we see what is close to that of English text (if spaces are included), but smeared out somewhat. It is still too close to English to have been from a Vigenère cipher with a period even as short as two.



First and dumbest solution

The first thing we should do is stare at the ciphertext. And stare. And stare. Then we might notice that the sequence `RHEB` occurs quite frequently, and that it is always preceded by one of `@`, `A`, `B`. It is reasonable to guess that `RHEB` < `the_`, and that the character preceding it represents a space. Also, we can see some plaintext characters leaking in sequences such as `CJFFICULRB`, which could be from `difficult`, and `FZDSOXICDB`, which could be from `hydroxide`. Notice that in these three examples, letters from the ciphertext are never more than two places away from their corresponding plaintext letters. Let's take another look at the monogram frequency (blue), but compare it to English text with spaces included (yellow):



From the smearing of the monogram frequency distribution and the examples of probable cribs, it seems to be a good guess that each plaintext letter is encrypted to a letter that is shifted at most two from its original position, with wrap-around, i.e., modulo 27.

Guessing the best decryption of a sequence of ciphertext characters is not always easy, so this block of Python code comes in handy:

```
alphabet = "@ABCDEFGHIJKLMNOPQRSTUVWXYZ"

def acceptable(a,b):
    for i in range(len(a)):
        if (alphabet.index(a[i])-alphabet.index(b[i]))%27 not \
                in [25,26,0,1,2]:
            return False
    return True
```

```
while len(ciphertext) > 0:
    output = ""
    for word in words:
        if acceptable(word+"@",ciphertext[:len(word)+1]):
            output += word + " "
    print(output)
    ciphertext = ciphertext[len(word)+1:]
```

It may not always find the best choice, but we can use it to spend the next five hours piecing together the plaintext.

Second, less dumb solution

By now we should have a lot of ciphertext/plaintext pairs that we can examine; for example, `FEBVYAUBSET@` < `heavy_water_`, `RVBMLOUBREBMA` < `swallow_team_`, and `CJCB@MCFENJRSENB` < `die_alchemisten_`. By studying them, we can see that the encryption of each letter depends on the preceding plaintext letter. We can tabulate them like this, with the preceding letter designating the column, and the current letter the row:

	_	a	b	c	d	e	f	g	h	i	j	k	l	m	n	o	p	q	r	s	t	u	v	w	x	y	z
_		A	B	@	A	B	@	A	B	@		B	@	A	B	@	A		@	A	B			B		A	
a	@	A		@	A	B	@		B	@		B	@	A	B	@	A		@	A	B	@	A	B		A	
b	@	A				B				@				A						A							
c	C	D		C		E				C			C		E	C				D		C					
d	C	D				E				C			C		E	C			C							D	
e	C	D	E	C	D	E	C	D	E	C	D	E	C	D	E		D		C	D	E	C	D	E		D	E
f	F	G			G	H	F			F			F		H	F				G							
g	F	G				H				F					H	F			F			F					
h	F			F				G											F	G	H			H			
i	I	J	K	I	J	K	I	J	K			K	I	J	K	I	J		I	J	K	I	J	K	I		K
j	I											K							I								
k	I	J		I						I					K				I			I					
l	L	M	N	L		N				L		N	L			L	M		L	M	N	L					
m	L	M			M	N				L				M		L	M		L			L				M	
n	L	M				N				L		N			N	L			L			L					
o	O		Q	O			O	P	Q	O			O	P	Q	O	P		O	P	Q		P	Q			
p	O	P				Q				O				P		O	P			P		O			O	P	
q	O																			P							
r	R	S	T	R	S	T	R	S	T	R						R	S		R	S	T	R					
s	R	S			S	T			T	R		T	R		T	R	S		R	S	T	R				S	
t	R	S		R		T	R		T	R			R		T	R	S		R	S	T	R			R		
u	U	V	W	U	V	W	U	V	W	U	V			V	W	U		W	U	V	W						
v	U	V				W				U					W	U			U								
w	U					W							U			U			U	V	W						
x						Z										X											
y		Y	Z			Z			Z				X		Z	X			X	Y	Z		Y				
z		Y								X																	

There is clearly a pattern in both the horizontal and vertical directions, and we can fill in the missing entries:

	_	a	b	c	d	e	f	g	h	i	j	k	l	m	n	o	p	q	r	s	t	u	v	w	x	y	z
_	@	A	B	@	A	B	@	A	B	@	A	B	@	A	B	@	A	B	@	A	B	@	A	B	@	A	B
a	@	A	B	@	A	B	@	A	B	@	A	B	@	A	B	@	A	B	@	A	B	@	A	B	@	A	B
b	@	A	B	@	A	B	@	A	B	@	A	B	@	A	B	@	A	B	@	A	B	@	A	B	@	A	B
c	C	D	E	C	D	E	C	D	E	C	D	E	C	D	E	C	D	E	C	D	E	C	D	E	C	D	E
d	C	D	E	C	D	E	C	D	E	C	D	E	C	D	E	C	D	E	C	D	E	C	D	E	C	D	E
e	C	D	E	C	D	E	C	D	E	C	D	E	C	D	E	C	D	E	C	D	E	C	D	E	C	D	E
f	F	G	H	F	G	H	F	G	H	F	G	H	F	G	H	F	G	H	F	G	H	F	G	H	F	G	H
g	F	G	H	F	G	H	F	G	H	F	G	H	F	G	H	F	G	H	F	G	H	F	G	H	F	G	H
h	F	G	H	F	G	H	F	G	H	F	G	H	F	G	H	F	G	H	F	G	H	F	G	H	F	G	H
i	I	J	K	I	J	K	I	J	K	I	J	K	I	J	K	I	J	K	I	J	K	I	J	K	I	J	K
j	I	J	K	I	J	K	I	J	K	I	J	K	I	J	K	I	J	K	I	J	K	I	J	K	I	J	K
k	I	J	K	I	J	K	I	J	K	I	J	K	I	J	K	I	J	K	I	J	K	I	J	K	I	J	K
l	L	M	N	L	M	N	L	M	N	L	M	N	L	M	N	L	M	N	L	M	N	L	M	N	L	M	N
m	L	M	N	L	M	N	L	M	N	L	M	N	L	M	N	L	M	N	L	M	N	L	M	N	L	M	N
n	L	M	N	L	M	N	L	M	N	L	M	N	L	M	N	L	M	N	L	M	N	L	M	N	L	M	N
o	O	P	Q	O	P	Q	O	P	Q	O	P	Q	O	P	Q	O	P	Q	O	P	Q	O	P	Q	O	P	Q
p	O	P	Q	O	P	Q	O	P	Q	O	P	Q	O	P	Q	O	P	Q	O	P	Q	O	P	Q	O	P	Q
q	O	P	Q	O	P	Q	O	P	Q	O	P	Q	O	P	Q	O	P	Q	O	P	Q	O	P	Q	O	P	Q
r	R	S	T	R	S	T	R	S	T	R	S	T	R	S	T	R	S	T	R	S	T	R	S	T	R	S	T
s	R	S	T	R	S	T	R	S	T	R	S	T	R	S	T	R	S	T	R	S	T	R	S	T	R	S	T
t	R	S	T	R	S	T	R	S	T	R	S	T	R	S	T	R	S	T	R	S	T	R	S	T	R	S	T
u	U	V	W	U	V	W	U	V	W	U	V	W	U	V	W	U	V	W	U	V	W	U	V	W	U	V	W
v	U	V	W	U	V	W	U	V	W	U	V	W	U	V	W	U	V	W	U	V	W	U	V	W	U	V	W
w	U	V	W	U	V	W	U	V	W	U	V	W	U	V	W	U	V	W	U	V	W	U	V	W	U	V	W
x	X	Y	Z	X	Y	Z	X	Y	Z	X	Y	Z	X	Y	Z	X	Y	Z	X	Y	Z	X	Y	Z	X	Y	Z
y	X	Y	Z	X	Y	Z	X	Y	Z	X	Y	Z	X	Y	Z	X	Y	Z	X	Y	Z	X	Y	Z	X	Y	Z
z	X	Y	Z	X	Y	Z	X	Y	Z	X	Y	Z	X	Y	Z	X	Y	Z	X	Y	Z	X	Y	Z	X	Y	Z

We can reproduce this table by expressing each character as three digits in base 3, and replacing the least significant trit (base-3 digit) with the one from the previous character. Understanding the cipher this way allows us to decrypt each character by looking at the character that *follows* it. This chunk of Python code does it quickly. Notice that we have to add a @ character to the end of the ciphertext in order to decrypt the last character.

```
alphabet = "@ABCDEFGHIJKLMNOPQRSTUVWXYZ"

ciphertext += "@"
plaintext = ""
for i in range(len(ciphertext)-1):
    plaintext += alphabet[3*(alphabet.index(ciphertext[i])//3) +
                          (alphabet.index(ciphertext[i+1])%3)
                          ].replace('@',' ')
```

Third and best solution

Remember that bit about a combination lock? How can we generalize this cipher to more closely resemble such a lock? Instead of only shifting the least significant trit (ternary digit) by one, why not allow all three trits to shift by different amounts? We will have to roll the ends around to the beginning, just like the wheels in one of those locks that have three or four digits showing (not like the ones with one wheel that you turn right, then left, then right again). The key would be three numbers, and encryption would amount to spinning the three wheels, thereby mixing the trits (we call this *fractionation*).

Here are some Python routines that implement the cipher we are describing. The key is now a triplet of integers. Decryption is the same as encryption, but with the inverse of each number in the key.

```python
alphabet = "@ABCDEFGHIJKLMNOPQRSTUVWXYZ"

def process_text(text,key):
    trits = []
    for _ in range(3):
        trits.append([])
    for i in range(len(text)):
        trits[0].append(alphabet.index(text[i]) // 9)
        trits[1].append((alphabet.index(text[i]) % 9) // 3)
        trits[2].append(alphabet.index(text[i]) % 3)
    trits[0] = trits[0][-key[0]:] + trits[0][:-key[0]]
    trits[1] = trits[1][-key[1]:] + trits[1][:-key[1]]
    trits[2] = trits[2][-key[2]:] + trits[2][:-key[2]]
    result = ""
    for i in range(len(text)):
        result += alphabet[9*trits[0][i] +
                           3*trits[1][i] +
                           trits[2][i]]
    return result

def encrypt(plaintext,key):
    return process_text(plaintext.replace(' ','@'),key)

def decrypt(ciphertext,key):
    return process_text(ciphertext,(-key[0],
                                    -key[1],
                                    -key[2])).replace('@',' ')
```

The key for the ELITE ciphertext is (0,0,1). The full plaintext is in the Appendix. So far, I have not found any hidden messages in it.

Cryptanalysis of the ELITE combination-lock cipher

To crack a ciphertext that was encrypted with the ELITE combination-lock cipher in a manner that is faster than brute-forcing the three integers in the key, I am going to use only one statistic: the index of coincidence (IoC). I use a normalization such that the IoC of a random string of characters is close to 1. Here, 27 is the number of characters in our set (the alphabet), n_i is the number of occurrences of character number i, and N is the total number of characters in the ciphertext.

$$IoC = 27\sum_{i=0}^{26} \frac{n_i(n_i-1)}{N(N-1)}$$

The algorithm is this:

1. Fix the first trit of the key $k_0 = 0$.
2. Vary the second trit k_1 over the values 0 to the length of the ciphertext - 1
3. Whenever the IoC of the resulting plaintext is greater than 1.5 (in my normalization), vary the third trit k_2 over the values 0 to the length of the ciphertext - 1.
4. If and when the IoC of the resulting plaintext is greater than 1.8, output the plaintext and exit.
5. Adjust the beginning position of the plaintext.

The last step is necessary because we cannot automatically find the starting position of the plaintext; we are only able to determine the relative shifts among the three key numbers with a program.

Here is a short Python (version 3) block that implements all but step 5 of the attack:

```
alphabet = "@ABCDEFGHIJKLMNOPQRSTUVWXYZ"

def index_of_coincidence(text):
    counts = [0]*len(alphabet)
    for i in range(len(text)):
        counts[alphabet.index(text[i])] += 1
    numerator = 0
    total = 0
    for i in range(len(alphabet)):
        numerator += counts[i]*(counts[i]-1)
        total += counts[i]
    return numerator*len(alphabet)/(total*(total-1))

key = [0,0,0]
for key[1] in range(len(ciphertext)):
    plaintext = decrypt(ciphertext,key)
    ioc = index_of_coincidence(plaintext)
    if ioc > 1.5:
        for key[2] in range(len(ciphertext)):
            plaintext = decrypt(ciphertext,key)
            ioc = index_of_coincidence(plaintext)
            if ioc > 1.8:
                print(plaintext)
                print(key)
                exit()
```

In the Appendix is an extra ciphertext on which you can practice the attack.

Appendix: 9B ciphertext

```
-..- -... --. --. ..-. --- - -.. .. ...- ..- .- - ..- -... --.
--. ..-. -- / ...- --.- / ..-. .-. .-. ..- --. .-.. --.- -.. .-- ....
/ ... - .. ...- . -..- -- ... .-. .-- / -.- - .-- / -.-- -.
--- ...- ... -.- - --.. / ...- -- / -... .--. -- / . -. ...- -..- .-
- / --.. -... -.-- -. . -- -.. / . --.. / ..-. - --.- / ... -.
--. ..- .-. . -.-- -. .- --.- / --. .... -.-. -.. / .-.. - .-- --.
-... .--. .-. .-- .. .... .. --. - -..- ..- - -.-. ... -..- -
-.-. .... .. / ..-. ..- .... .. . -.. -.. ..- -... / -.- ..-. / . ...
.- ..-. .-.. ... .- ..-. / .-.. -- - -- -... .... --. / -- -.-- .--
--- .-.. -.-. -. ... / -. --- .--- -.- / ... .-- -.-- -.. / -.-- -..-
--.- -..- ..-. .. .. .-.. -.- / .-. -- / --. --.. ..- -.. / .-. . ...
.--. --- -. ... .. -... .. .-.. .. - -.-- / --. .--. ... / ..-
--. . .-- - -.- ...- .- / .-. .. / -..- .-.. .. / .-- - --.- --.-
-. ... .-.. / -.-- --.. ..- .. --.- / --.. .- ...- .-- / .-.. --.- --
/ .--- ..- .-.. --.- -. ...- .-. -... -.-. -. .-- / -.. -.-- /
-.-. .--. . .-.. - -.-- / .- .... --.- -.. -- -..- -..- / .--. -...
--.. --.. -. .- --.- / -.-. - / .. .-- - / -.-. -.-- .. .. -.-- . -..
/ .--- -.- ..-. --. / --. .... .-- .--- ... .-.. .- --. ..-. ...
-.. / ...- .... --. -- -.- .... . / ..-. -.-. -.-- -- / .-. -.. ---
-.-. / .--. -.. .- / -.-. -... .. .- -.. -... -.- .- -..- --- .---
-... --- ..-. -... / --.- .-. -- -. / ... --.- --.. -... .--- / .- -.
-.. / ..- ... -... .--- --- / ..- --. . .-- - -.- ...- .- / .-.. ...-
/ -..- .-.. .. / .-- .--- -..- ..- - ... -..- -. --. -. --.- -. -.--
-.. / ..- .-.. / --. -... -. -.. .... .--- --- / .- -... .--
-..- / .-.. -..- -.. .-- -.-. -. .- .-. .-- -.-. -. ..- ..- .-. .--.
-. .-- .-.. -. / -.. -.-- / -- .--. / ..-. - --.- / . .-. ..-. -.-.
-... .- ..-. ...- --- ...- -.-- ...- --. .-.. / -.-. - / .. .-- - /
--.- .-. -- ..- -..- .... / .--- -.- ..-. --. / .- ..-. .-.. .-- -..
-.. .- -.-- .-- ..-. ..- .-- / ...- .... --. ...- -..- -.- --. -...
--. --.. / ..- ..-. ..-. / ...- -. -.- --.. -..- --- -. / -.- -... /
--.- . -... / -.- --. --.- --.- --. -- .-.. / ... -. / -... . /
-.. .--. .--. ... . .--- --- -... ..- ..-. . / -..- -.- -.-. / .--
-.- .... / .-- -- --. .-.. .. ...- .-.. .. -- -..- .-- .... -- .. .-.
.-- -..- / -..- -.-- - ..- / ...- .-. --. - --.. / -.- .--. -.-- .-..
.--- .- ...- -.-- / .--- .-. .. --.. ...- -- / .-- .-. ..- -... -...
-. .-- / ... -.-. / -.-. .--. -.. .- --.. -.-- -.. -
-- .-- .--. / .-. .- -.. / -.-. . .-. -.-. -. . -. --. ...- -... .- /
-.-. - / .. .-- - / .. -..- -.-- ..-. -.-. ..- -.. .--- / .---
-.- ..-. --. / --.. .-- / .- - .-.. / -.-. .... --.. .. .-.. --. -.--
-..- / .--. -. / .--. -.. .-- .--. / . -... / ..- --. .--- .--- / .-
-.. / .-. . .- -.. -.-- / ..- .--. / ..- .--- -.- .-. / .--
-.- .... / -- -..- .. --.- / - ... / -.-- .- - .--- --. . / .-
-.. .-.. ..- .- .--. .-.. .- --- / -. -- .--- --.. -.-. .. --.. --. /
-... -.-. -..- -.-- / --- ..-. --- -... .. -.-- -..- --- / - -.-- --.
--.. .-- --. .--. --- / ..- --.. / --. ..- .-. / --. ...- .--
-.. .- ... -... .... / .. -.. / .-. ..- / -- ...- -.- -.- ...- ..- /
```

```
- --.- / -- .- -..- / ..-. .. .-- ..- ..-. / -. -..- -.-. .--.
--- ..- -. --- ...- .- .- --.. --. / --- .--. -.- .-.. / --- -...
-- .-.. --- --.- .--. / -- -.. / --.. -- -..- / .-. . ... .. ... - .-
-. -.-. . / -... -.. ..- .--- .-- .--- ..- --.. / -.-. -
--. / .-- .-. / ..-. .. / -.- - .-- -... ..-. .-- .. .--- .. /
--.. ..- / .- --- .-.. / .. .--- . -- .--. --.. / -... -.-. -..- -.--
/ -- -.- -.-. ..- -.-. / . --.. / -. --.- / . .-. .--- .-. ...- - ..-
.-. --.- / --- .... / --. -.-- .--- --.. .--.
-.-. / .--- . / ...- . .--- .-.. .. ...- / .-.. --.. .-- / . ....
- .-- / -... ..- -- / .. .--- --- / -..- .- .- .--- / --.- -..- .---
-- -... --- -... .- / ..- --. .-. ..-. / .-. ... -. --- / .... .- -.
-.. --- ...- . .-. / ..- .--. / -.. --. / .--. .-.
--.- .-.. .-- .-. ..- .... --. / --. .--. ... .-- .. .--. -.-. / ..-.
-.-- / -.- -... -.- -..- . / --.. .- .... -. .-.. / .--- --. / .. -..
.--. ..-. .--- .-.. --.- / -.-. -.. -.-- --.. / .-.. .-- .-- / -.. .-
-..- -..- ..- --.. ... / ..-. --. -... .--. -..- / .... -.-. / --.- -
/ -.-- -.. .. ..-. ..- ... .--- ..- - / -.- -.-- ..-. .. ..-. .-..
-..- -.-- -.-. .--. / - --.- / .--. -..- .- -.- ..-. - ...- .-
-- .-.. -- -.- -..- -... -.-- -..- --. .-- -... -..- --. .-..
-- / ...- -.-- --.. .. .-.. -.-- / --. .--- ...- -.-- -.. .. -... /
--- .--. -.- .-.. / .. .-.. -..- .- ..-. -.- -.. / -. .--- -.-- .-.
-.. -- .--. -.- --.- / ... -. / -... . / .--- --- - --.- ..-. -.. ..-
..-. . / ..-. -.-. -.- -. .- / -..- --.- .-- .-.. --- /
-..- .-.. .. / -..- -- -. ..- .-. .--- ... -.-- / --. - .--- /
--- ...- -... -.-- ... ..-. / .-.. -.-. --.. --.- ...- --- / -.-.
--.- -. / -.-- --.. --- -... -.- -.. ... -.-- -..- / -.. . --.. .- /
-..- --.- -- .... --.- / .--. -. .- .--. .-. -.-- -.-- .-. --.- / -
-.-. ..-. / .--. .- .- / .--- .... . . ..-. .. / .-. . ..- / .... --.
-.. .- ..- .-- / .-.. -- .... .. / -.-- .--. -.-- .-.. ... / ...-
-- .... - / --.- .--- . .--. / ..-. -.- / .-. ..-. -.-. / ..- ....
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Appendix: 9B plaintext

waffenschutzstaffel to coordinate operations for shipment of the vemork product to the fatherland stop

wehrmachtstreifendienst personnel to maintain station security stop

wach bataillon to have responsibility for security of the rolling stock stop

die alchemisten to retain overall command of the mission stop

operational control lies with the feldgendarmerie stop

track and train security is the responsibility of zugwach stop

counterintelligence to be the responsibility of the abwehr stop

intelligence concerning all aspects of the mission to be coordinated via the sicherheitsdienst stop

plant director bjarne nilssen is responsible for preparation of the shipment stop

he has informed us that he will be ready to ship the item on sunday twentieth february stop

everyone involved in the shipment to be vetted by the local schutzstaffel stop

reports of any resistance activity are to be forwarded to the abwehr stop

casks to be reweighed at rjukan to ensure the load has not been tampered with stop

handover to be monitored closely at every stage by zugwach stop

all rolling stock to be inspected thoroughly by wehrmachtstreifendienst before loading stop

loading platforms to be inspected daily until the shipment and hourly during the operation stop

leave cancelled for all troops and police stop

every army unit in the vicinity is required to provide guard patrols for rolling stock route stop nielsen to be instructed to organise the transport of the shipment stop

geheime feldpolizei to monitor staff at every station and on every train stop

entryways to the plant and rail facilities to be guarded by wehrmachtstreifendienst personnel at all times stop

doors to the storage and transport facilities to be locked at all times stop

outside the logistics team and local security operations only officers of the ss and members of die alchemisten can be copied into the plans stop

tinnoset to be prepared to receive the shipment but no indication should be given of the nature of the cargo stop

orders for onwards shipment from tinnoset will be provided separately stop

rjukanfos to be prepared for shipment as a decoy stop

guards to be placed in prominent positions on this vessel stop

sf hydro to be used to ship the product stop

loading plans to be established for a dummy cargo on sf rjuakanfos stop

additional security measures should not be put in place on the landing stage for sf hydro stop

security routines must be maintained in order to reinforce the decoy on rjukanfos stop

heavy water to be kept under observation at all times stop

extra security to be provided on all transport until the cargo has reached die alchemisten stop

local officials and employees are to be assumed to work for the resistance unless vetted stop

information about the shipment should be encrypted using high grade field ciphers stop temporary security measures can only be lifted once the cargo has reached the next staging post stop

extra resources can be provided for all aspects of this mission on request to die alchemisten stop

Appendix: ELITE ciphertext

```
UHKLC BRHEB URAAG @@QLA KLHAR @JCAI LBLQU DNAET @F@JL CEARQ @C@VR
DBLVC FBCAM AGDBR Q@RHE BFEBV YAUBS ET@OS OCVCR KOLBC @PADI RZA@S
BRHEB OM@MT BIRB@ EE@MD BCLCB S@RQ@ RHEBL BYK@O FFICI @MRAR HBSBR
HEBF@ DRQRX AUBSA LQ@LO LHDT@ RAGCB CJCB@ MCFEN JRSEN BUETC BILHO
RLDEA @MEAR ULCEA RHBSB RHEBL PCDT@ SQR@U QULCA @EBRA GCT@R SQRCE
AILBF DTLAM ZAUHE TCBIR BUQUL CA@MR P@@EB CLORD T@RQ@ RHEKR @CZOD
TILDN TBM@F @DILI RKCTS HEBOO DT@SK OLBRQ @LPUD BRHEB RCNAJ LKLHA
RSQCI TAOF@ OPRBS SJULA FZDSO XICDB FROLA UHKCF BRHEB FEBVY AUBSE
T@UBS ARQ@@ EBCZR T@DRE EAUBS AOM@M NEEAF OR@LJ CGCBT U@SXA @MEA@
QRSAU BSA@M CTREE ARQ@R HEBOM @MB@Z ALDNA ETRAO F@RHE BRVBM LOUBR
EBMAU HQ@RC NAJLE EAILB COLTB DRBUK RHBLO XAM@L QRUEH J@MTA UQRIK
LHA@S BRHEB OM@MT BRHEK R@ILT EN@@M LOUEE A@ACO ULTET OODT@ SKOLB
RQ@@E BOSCQ ASCEJ LKRK@ M@RVR UDKLL @MECB RGQUE EARHB SBRDE URIRZ
AOLBR HEBR@ JL@LI LEBRH BSBUQ ULCAC @SRXA RHEBC @SFP@ FBDA@ EENBR
SEQPD EAUOA FOLLO UKLHA RHEB@ QLAKL HAR@J CSAUK RHBLO C@M@C IUJLI
@MTAL Q@LOL HDT@@ MLOUE EARQ@ RT@VD N@OLB RHEBR T@JLT A@MEA ILERC
BSDEA FV@SC AOAST OLRAR AAQRB GDBOF @RHEB R@JLU BYALI LEBUB SALQR
BFCBS J@NCB @MEAI LB@MZ AC@SD BIRBU QULCA @EBCJ FFICU LRBRQ @OM@M
TB@AC FBSFD BCJRS UOSKU DBCNQ UFGBR Q@CAM AGDBR HEBC@ SFP@A CDEIR
JOLBU BSARB JENBI LTSEB DARQ@ LJLEB RHEBF WLL@O F@RHE BRG@F ZDSO@
@QRSA @GDNT TAILB RHEBO M@MTB UETCB @ANCB RQ@CD TETLJ LEBRH EBRGK
OPJLH ACASE B@MEA ILBOR CDT@R Q@LJL KLJXE BCIUJ LI@MB C@SV@ MRKCT
AIKDN L@LKC NRDNB CDN@Y DEARH EBCDE @MTBO F@RHE BOPRB SSJUL AFZDS
OXICD BFROL ARHEB RSQR@ GDBRB MKTAI LKRK@ MLXAR HEBRS AFBDA FQODE
ARQ@R GKOAO LBRHE BRASW RCAYA UHENB RHEBF CTRIC TAUET CBRZP JC@ML
XAUDT XA@WR YARHE BCDN@ YALPU DEARH EBRGK OMDNT BRQ@R VLEAY ARCEV
CILHA RHEBL WLAET @OF@O ASSDN HDTRA ZARJL KKLHA RHEBF CTRXA ILBRH
EBCDE QDTSB OASRB OF@L@ JEBRK LNBRH EBRAA QREWR RAFQO DBRQ@ OSCWD
NTBRH EBLBY KRAFR OLARC EOUDT ILHAR HEBC@ SFP@C ZODTI LDNTT ACOLW
JLECE ARHEN ARHBS BRHEB LPRSB CHFCE RKUDB UBYAR Q@CNT VRCBR HBSBR
HEBFC TRXAC OULCA LQRB@ EBRCT DUCEA UBSAR Q@@NO UBOUR B@ARP W@SCB
RDERK OLBOF @RHEB FWLL@ @ZARH EBOSO UB@ZA RJLKK LHARH EBOSO UBFIR
RSBRH EBRGK OSARS EET@G DBUQU LCA@E BLIFR EEAOU RBOF@ RHEBU BSET@
LCBVJ LHARH EBCRC WBUKR HBLQ@ COLTT OL@RH EBREB MAUET CBCDT ETLJL
EEARH BSBUH KLCBR HEBCZ OMORJ OLBFB DARQ@ @EBL@ SFDBC NQUFG BRQ@C
@VRDB F@SBM @CAMA GDBRQ @RHEB RGKOA IRBFB DARQ@ LCBVD BRKLD BFOR@
RHEBO ASSDN HDTRA @MEAC RCWBR Q@CWA DU@SE BRHEZ A@WIL RBRHE B@QLA
BFROL ACKFG TEENB OPULE SAOF@ OM@SS KC@IL KRK@M @OM@M TARQ@ URDBF
URDTA LCHRB OUDT@ FROLA RHEBR VCCCT SGUL@ UDNPR IBRAA QRBGD BOODT
@SKOL BUETC BRQO@ RGQRR BFOR@ RHKRA @SARH EBRGK OAUQU LCARS KLL@@
EBCLO RDBRQ @RGQR CBUHE NBRHE BCZOM ORJUD TAUEN TBOFF @RP@R HEBRE
BMAIL PSOUJ RDEA@ ARKLJ LHACD WJCCB URJLH A@MB@ M@SLA CLOCI BRHEB
RPW@D ACOLT JRSKL HAOF@ @MF@L @SRDN BINWR BLICT FBMTD NBROL F@RPR
LICB@ MEAIN WRBFB VIENI CA@SS DNANC EA@AF CWBIK LOLDT TCTAF ROLAR
HEBOW @YA@S BLADN @@MEA @PPSO @DFEE A@SBL KFGTB RHEZA CURBR HTOUF
GB@AF CNECB @MEA@ Q@SCD EARHE BRGKO AUHET CBRHE ZAUET CBCJR DOUDT
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CEA@Z A@AOA STOL@ LICTF BMTDN BRTIC EARQ@ COLWJ LECBR HEBFV @SCAR
HBSBR HEZAU ETCBO ASSDN HDTRA UHQ@I VRSBU BMTEE ARQ@R MCEQA OLBRH
EB@Q@ SB@WR BFEBU BSAUL EOLWJ LECEA RDNTJ LHARH BSBRH EBFEB LJFGT
B@EBR YMPAS HETKC @RHEB REBMA @DMJR TEEAR HBSBR HEZAU QRIEE AFOR@
RHEBR CTJRS BMECB @MEAR QLCAR HEBFV @SCAR HEZAL EEEDE ARQ@@ EB@ML
OUEEA RQ@FK CDBRP LDTHK LHAOL BRHEB RGKOA RHKRA UQRIE EA@ME ARPRL
ICB@M EAFBV IENIC AUETC BODTL JRTEE ARQ@F P@@EN OUBCD EIBRQ @RHEB
IEEN@ UHETC BRHEZ ARPDN TBRHE BLEZR BRWQ@ FQURR AOM@D ILHAC ZOMOR
JUDTA UHENB RHEZA FBDAF ILKRG EEARH EBRAA QREWR RALCH RBRHE BRGKO
AUKRH QURB@ MZAFU RRHET @CFBM LCNHD THEBL EZRBL PRLKL HARHE BCDWJ
CCBCZ OMOCD EA@SA OM@MN EEAIV RSB@S ARHEB L@DDN BRGKO ARCBD FEEAR
HEBUR CAMCN BLIFG THQUR DBIRB RWRLE EAILM DEJ@S ENXAF OR@RG QRCB@
WRBRH EBCAM AGDBU BSARQ O@RDW DTCB@ MEARH EBRGK OALIR SEEAO WICIN
XARHE BRGKO ARAMK B@SBR ENBRH KRRZA RDTTN ILHAO LBRHE B@QRT QLAIL
BFOUR @FWLE SCEA@ MEARH KRRZA LDTET RARHE BLIFC BQ@ST AUETC BLQRB
CDQMO XDEA@ MEAOA SSDNH DTRA@ MEACR CWBFB DALQ@ ILTST UCRKO LTAOL
BRHEB URDBO F@LIF CBENR TARP@ C@SV@ MRKCT AUETC BULBV PICAA NCB@W
RBF@S LDTRA FROLA @DROR SARHE BL@JE BC@MD BRQ@R HEBRC TDUCB OF@RH
EBCRC WB@ME AOASS DNHDT RAFOU RREEN BLQRU EHJ@M BCRCW B@MEA OASSD
NHDTR A@MEA FOUR@ FDTLA MBRPL CJCTR ACJCE A@MEA CKFGT BCAYS A@GRE
T@RHE BILEI CDNTB OASSD NHDTR A@MEA CRCWB OF@RH EBRG@ RIVIB MHORA
LASIE EARHE BRJLK KLHAU KRHB@ ALDNP RI@M@ RDTUJ CCTHE BC@SV @MRKC
TAUET CBLPR SBRCH SCTTB ANCB@ WRBRH EKR@C DBSHT AUETC BLQRB ILBUA
JLBRH EBC@S FP@UB SACDT STOXD EA@ME AIRBI RALII ENXAR HBSBR HKRAU
KLL@L ASIB@ MBCNE ARQ@R HEBFD TLAMB LWCLC BS@UE BPPLT AOSOF S@MMD B
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Appendix: ELITE plaintext

while the usaaf bombing raid in november failed to cause much damage to the heavy water production capacity at the plant it became clear to the nazi officials that the factory was no longer safe die alchemisten were informed and ruled that the moderator would be safer stored in germany where it would also be closer to their experimental facilities

the operation to move the remaining stocks of potassium hydroxide from which the heavy water was to be extracted was planned for midfebruary and boss was alerted to the plan by members of the swallow team who remained in contact with loyal norwegians working at the plant their intel allowed a counteroperation to be prepared

initial surveillance showed that security on the rail line that would carry the cargo had been stepped up following the bombing raids with local civilians no longer allowed to travel on the trains and increased guard patrols sabotage of the railway line was not feasible and in any case it would be difficult to plant a charge disruptive enough to damage the cargo

a decision was taken instead to mine the hull of the sf hydro boss agents in the plant were able to determine the shipping date and in order to minimize civilian casualties kjell nielsen delayed the decant of the potassium hydroxide from the storage tanks initially the ss had hoped to ship on the saturday when the ferries were typically very busy the delay moved the shipment to sunday reducing the number of passengers

by sinking the ferry in the deepest part of lake tinn the saboteurs hope to prevent the nazis from recovering the cargo experiments convinced them that the most effective way to ensure that the ferry could not be rescued was to blow out a square section of the hull by the prow by sinking the prow first the ships steerage would be lifted out of the water leaving the crew with no control the team were determined that while the explosion had to be large enough to cause fatal damage to the ship it had to leave time for the passengers and crew to evacuate they built the bomb from eighteen pounds of plastic initial plans to use fuses left over from the successful vemork sabotage operation were too short for this as the ship would still be close to shore when the explosives went off so the team improvised a timing device using an alarm clock the squad consisting of alf larsen knut lierhansen rolf sorlie and knut haukelid assembled a few kilometres from the quay at mael and approached at night they cut through a fence and boarded the ship where they were discovered by a patrol lierhansen tried to convince the guard that they were passengers who just wanted to sleep on the boat but he was unconvinced sensing that the he might be sympathetic the team admitted that they worked for the resistance and told the guard they needed to be allowed to hide something on the ship this worked and sorlie and haukelid were permitted to go below deck to the keel where they spent the next two hours placing explosives when they had finished the saboteurs left the ship without any further challenge

the next morning the device exploded as planned just as the laden ship reached the urdalen lighthouse it turned immediately for shore but the damage was too severe and the ship listed quickly the ship sank at ten thirty settling on the bottom in four hundred and thirty meters the lifeboats were not deployed and passengers and crew had no instructions on the use of lifebelts so casualties were unavoidable but farmers from across the lake came to the rescue of the crew and passengers fourteen norwegian crew and passengers and four german soldiers died and eight days after the incident passengers and crew of the sf rjukanfos marked the sinking with a memorial service

the casualties were most regrettable but their deaths were not in vain the cargo was destroyed and it is likely that this will mark an end to the german nuclear weapons programme

Appendix: Additional challenge using the ELITE combination-lock cipher

```
TNBUCKBEUEBKRLBQKIVODCRBBIEEUDJRHIBEWUI@FLBKTAABSTRXAIDLAGPKEPCIF@DUJ
@OLNM@VGTRC@EMSOIAWJISCOJGU@@GLITCTNBUCKTBIBZHICWRCREBBCXABSCRES@JLHE
@LCNVUAIKAWBWSFRB@ZAJJFWBPKFV@AGUIKINBWISRAO@GX@BPU@@IZNHXFRJCASBALGC
VLIKFLTFKRFBXCR@REKEL@LBDEDB@MWIKIGMJUEORBJICPCIHRD@AUU@KJ@UKUHSCB@T@
@DMIHDATSRXBIDLAGYTBDOX@XD@I@CCKSCSNAUA@NBCNJNBUGTABXEADRBBN@NRDFKCJA
EVUAISFKINAUOURI@BV@UJBRL@SDIIBEIEAFXEIVCIIQLNBECINOUNNUI@SDRB@HUBSLB
NBCWEIS@@BWNR@DCDTOIGWA@FUIVFBEKLW@@VRE@CET@@JBD@JD@VNRADVK@H@VERN@@A
EJXOIEBCI@CMRPSHUW@JRFBBAMLOLOV@IFMVC@SNAHNEIKVDQI@V@@GCIHIEWEI@FQIPM
L@CC@QILBEFJADCKMOVZDRC@AGINK@CZA@HLBDUEKBULHKNFLK@LUCEUCTI@OMNM@VGK@
FXBAGUIUFBET@KIFDUASF@EW@TH@EW@TELENRGBJNEU@RFBCU@TH@EW@BELBEUEKTO@KQ
BU@@CVIWAKQACTINEUNIBCI@ZB@WRTXAIVCJJAWBAGLINFWEBLECKEBZQBRERAEZCBD@Z
KN@EFKMV@BVRBRRTEIJHDB@AR@BIJLWHDCD@RRETD@A@CVW@RJ@FKPACEIOFCUW@@@OAW
CAIADVKAFMEJ@DAEX@SIIOZDT@@FCSMUEKBFX@@HC@CCBEKUGEAGICRE@KMOEEULR@CCB
XB@ABLEDSCBNWB@CUKV@BZA@HLTQ@KQBL@CIMOKM@CO@FZ@BGU@RLBNK@WB@PU@T@TWHI
O@WEIBFX@BY@@RCBKJHCW@AOUZBOTBT@@Y@IS@TBVB@@WCNMMFGEVK@FAEDFW@RATUHAK
OTERW@@RCBW@ACCRBGBTAITGIKTDRL@UCTBKCWBH@CZ@SSRXBJELJGYETJRXABIYHI@VU
@@@FDKAYASERK@GIVAIWXCA@GU@@FDJW@TWWIJIGL@GGIXHI@@CLCUKIPGTEIKLA@CSC@
INK@CFJ@ECBGIMKACHSCBUKS@CLKVTIAQLMLAVGBI@CESAIMBSRAAULRACEVKUFSES@WC
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