HamSCI

Ham Radio For Space Scientists

Carl Luetzelschwab K9LA

ARRL Central Division Vice Director

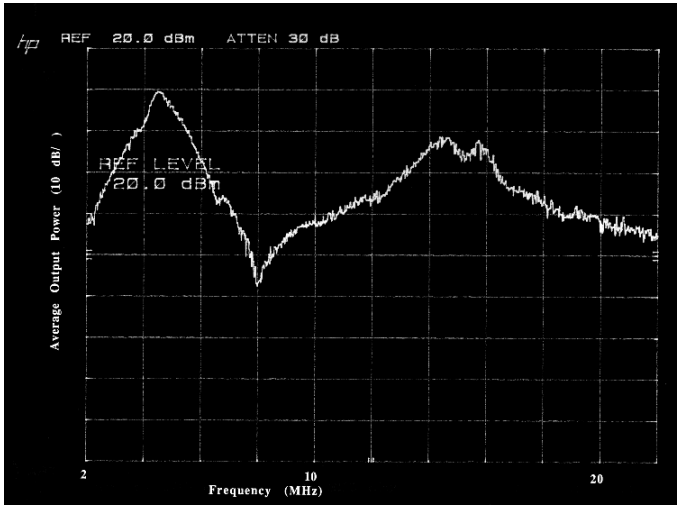
Amateur Radio propagation web site https://k9la.us

Agenda

I. Amateur radio – the early years
II. The Radio Act of 1912
III. Contribution to propagation science
IV. Collaboration with the scientific community
V. Areas of interest needing research

Amateur Radio – the Early Years

- After Marconi's feat in 1901, many private radio operators put together stations using spark gap transmitters
- A spark gap transmitter spectrum is very broad



x-axis is 2-22 MHz

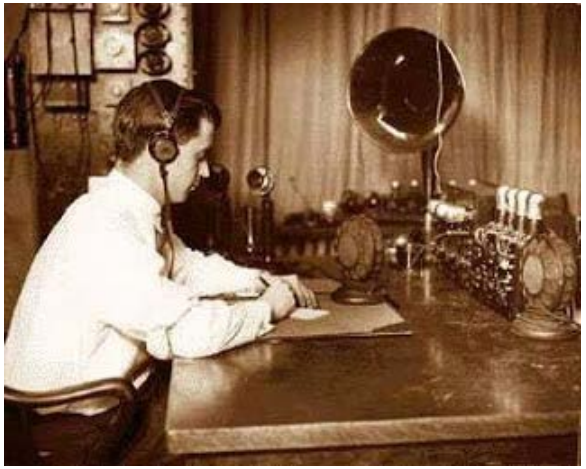
- Complaints received of interference to commercial and military communications

The Radio Act of 1912

- Private radio operators must be licensed
- Limited to 1 kW
- No more operation in the “prime” wavelengths of 1000 to 200 meters (300 KHz to 1.5 MHz)
- Moved to wavelengths shorter than 200 meters (frequencies greater than 1.5 MHz)
- 200 meters and shorter were considered a “wasteland” due to being limited to line-of-sight
- Amateur Radio operators (hams) developed a “we’ll show them” attitude
- And we certainly did! ☺

What Did Hams Offer?

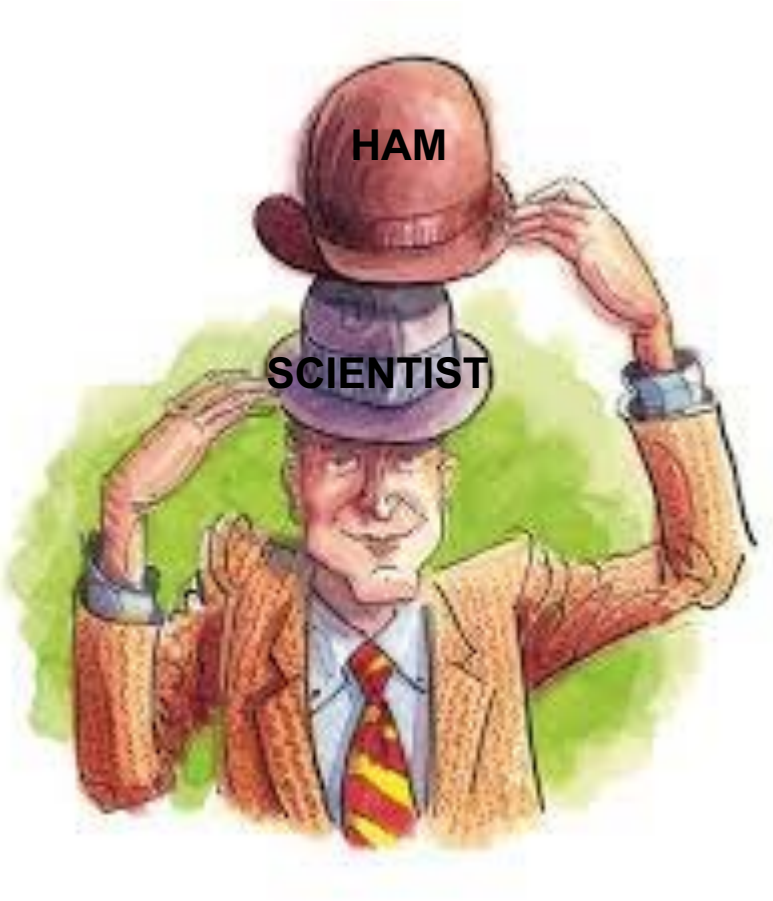
- Radio stations



- Basic understanding of “radio” and “propagation”
- Large numbers - 46,000 in 1936
- Wide geographic coverage both domestic and overseas

The Role of Hams

- Hams were considered to be “observers”
- Scientists were considered to be “theorists”
- But just like today, there were hams who were scientists – and scientists who were hams
- Nowadays our bands are from 2200m (136 KHz) to 2m (145 MHz) and above
- Approximately 800,000 hams in the US
- Over 1.2 million outside the US



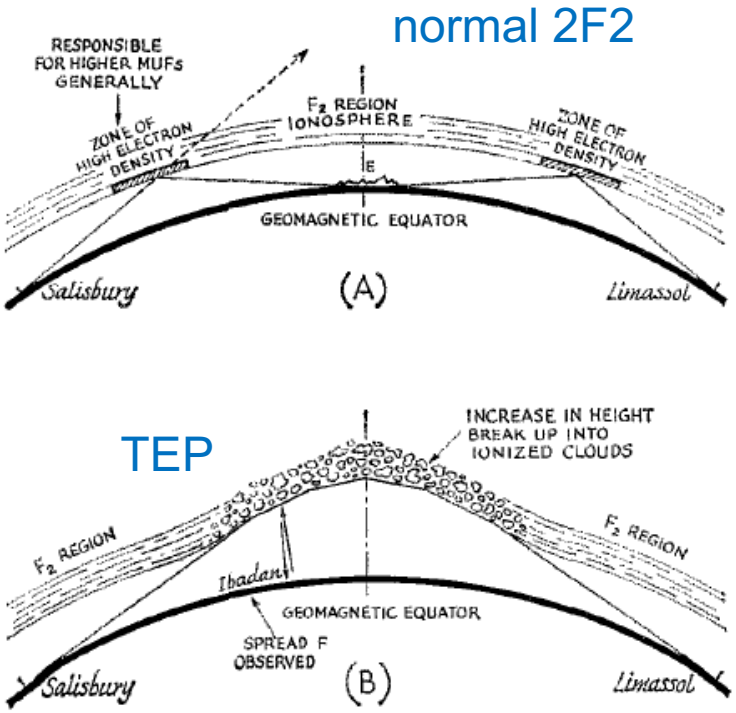
Pop Quiz !

What 1938 movie was this from?

hint: the main character is the girl on the right

Contribution to Propagation Science

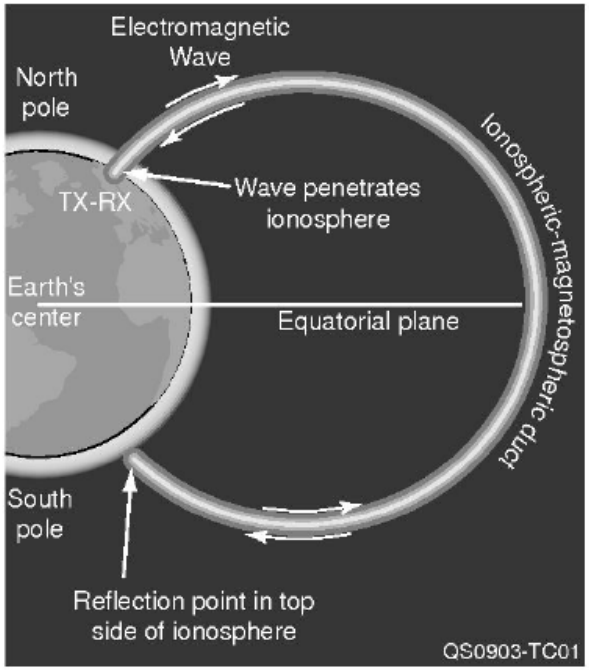
- TEP (trans-equatorial propagation)
- Discovered as a result of an August 1947 QSO between XE1KE and LU6DO on 50 MHz
- MUF (maximum useable frequency) too low for normal F2 region propagation
- First theoretical explanation by ZE2JV in the December 1959 QST
- Picture of TEP mechanism by 5B4WR in the April 1963 QST



Contribution to Propagation Science

- LDEs (long delayed echoes)
- First reported on PJCC in Eindhoven on 9.55 MHz during the summer of 1927
- Delay about 3 seconds – much greater than RTW echoes
- Article by Villard W6QYT in May 1969 QST
- 46 observations listed in the February 1970 QST – again, much more than RTW echoes
- Many more reports followed

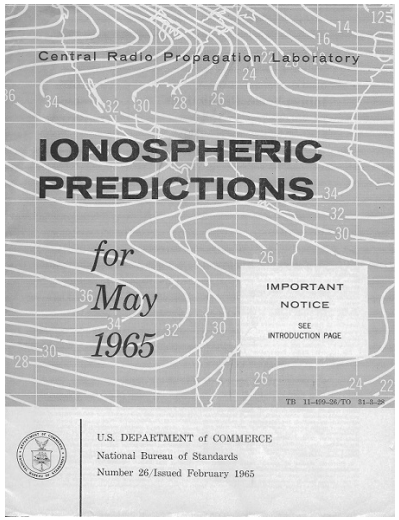
- Slow group velocity when Fop = Fp
- Magnetospheric ducting by LA3ZA

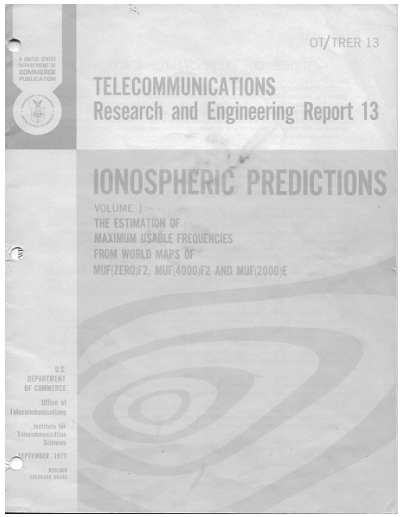


Contribution to Propagation Science

- MINIMUF by K6GKU in the December 1982 QST
- First propagation prediction software to run on home PC
- Eliminated tedious manual predictions
- 80 BASIC program steps
- Fit on a TI-59 calculator or a TRS-80 microcomputer

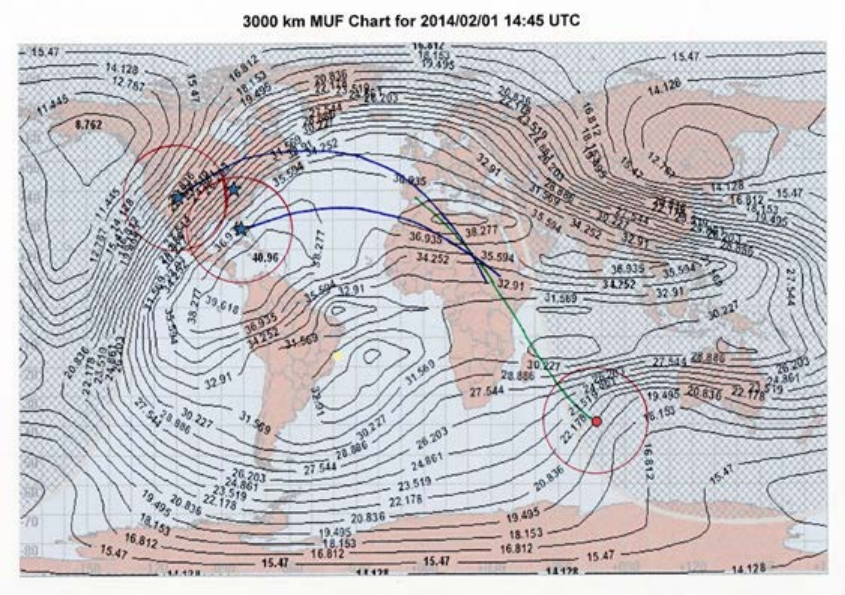
the old ways





Contribution to Propagation Science

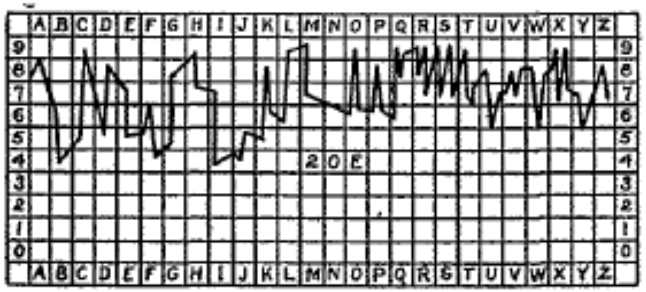
- DXpeditions - some hams like travelling to far away locations to contact other hams all over the world
- Over a 2-week period, tens of thousands of QSOs can be made all over the world on all HF bands
- The log can be analyzed
- Example: 10m QSOs from the January/February 2014 FT5ZM DXpedition to Amsterdam Island in the southern Indian Ocean



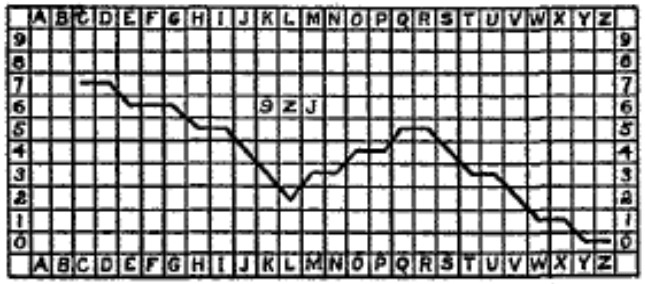
- True great circle short path not available due to low MUFs
- Paths with high enough MUFs and skew point allow QSO

Collaboration with Scientists

- Bureau of Standards requested hams to participate in fading tests in the summer of 1920
- Example: spark gap transmissions from 1AW in West Harford, CT to 2OE in Freeport, NY and to 9ZJ in Indianapolis on July 8, 1920



Transmission by 1AW July 8, 1920.



A. R. R. L. FADING REPORT

Receiving station call_____ Location_____ Date_____

Time observations begin_____ General reception this date_____

_____

_____ General character of strays

("static") this date_____

_____ Transmitting station call_____ Wave length _____m.

Weather, wind direction, and strength, indicated by check mark below.

Weather:	Wind Direction:	Wind Strength:
Clear	N	Calm
Cloudy	NE	Light
Rain	E	Medium
Snow	SE	Strong
Sleet	S	Storm
Fog	SW	
Lightning	W	
	NW	

SIGNAL STRENGTH RECORD. Indicate average strength for each letter by a check mark (√) in the proper square below.

	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	
Very strong 9		9
Strong 8		8
Good 7		7
Fair 6		6
Rather faint 5		5
Faint 4		4
Just readable 3		3
Very faint, unreadable 2		2
Just audible 1		1
Nothing 0		0
	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	

Fig. 9

_____ Receiving Operator

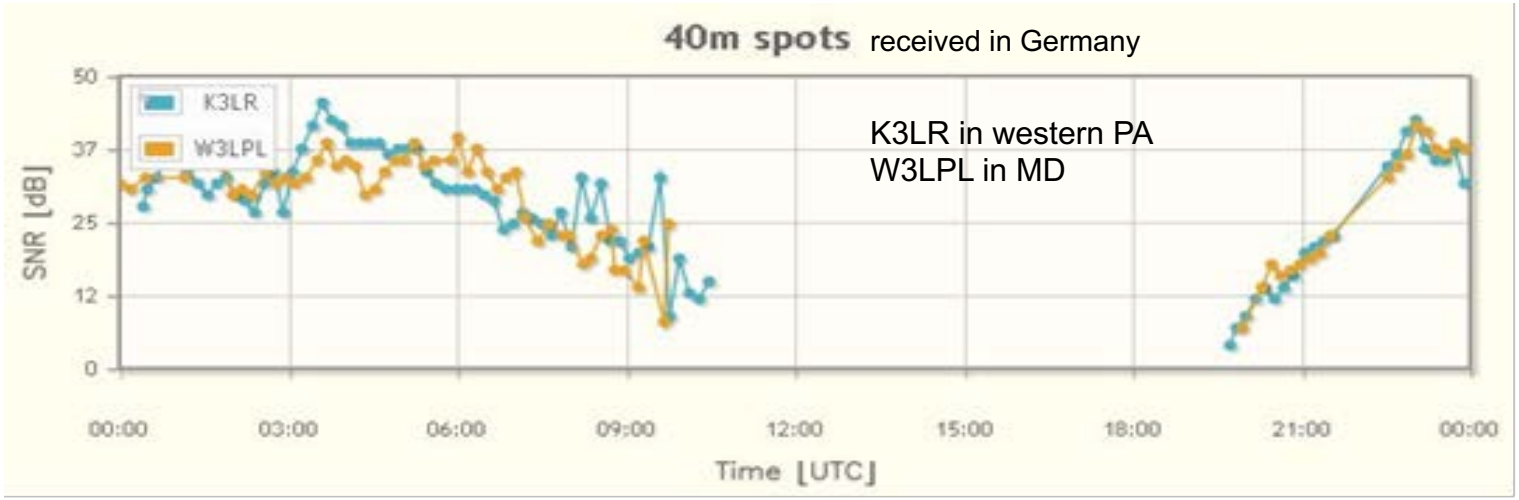
standard fading report form

Collaboration with Scientists

- ARRL-IGY Propagation Research Project from July 1957 to December 1958
- Tied to earlier discovery of TEP
- Collected reports of possible 50 MHz, 144 MHz and 220 MHz ionospheric propagation
- Generated nearly 300,000 individual reports from nearly 600 observers in 50 countries
- Lots of sporadic E data showing motion of ionized patches

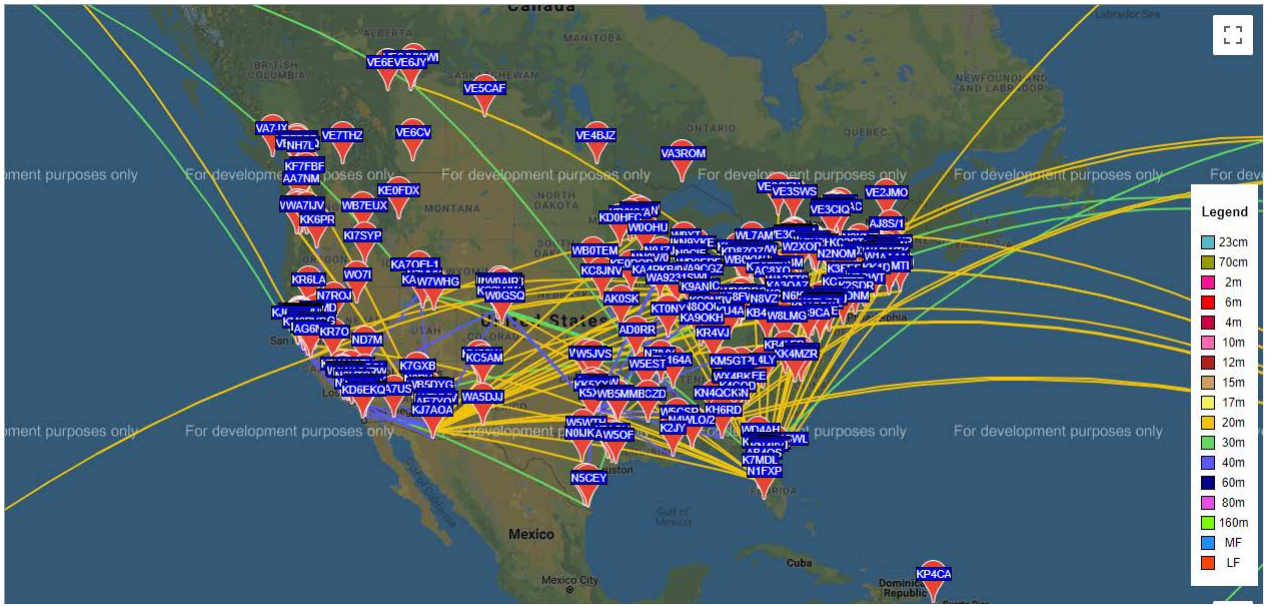
Collaboration with Scientists

- RBN (reverse beacon network)
- SDRs throughout the world to receive ham transmissions of specific format (CQ K9LA or TEST K9LA) – output is SNR
- Data for doing propagation studies (see next slide)
- Compare signal strengths of competitive stations



Collaboration with Scientists

- WSPRnet (weak signal propagation reporting network)
- Hams use K1JT's MEPT_JT digital mode (Manned Experimental Propagation Transmission) to probe radio frequency propagation conditions using very low power transmissions

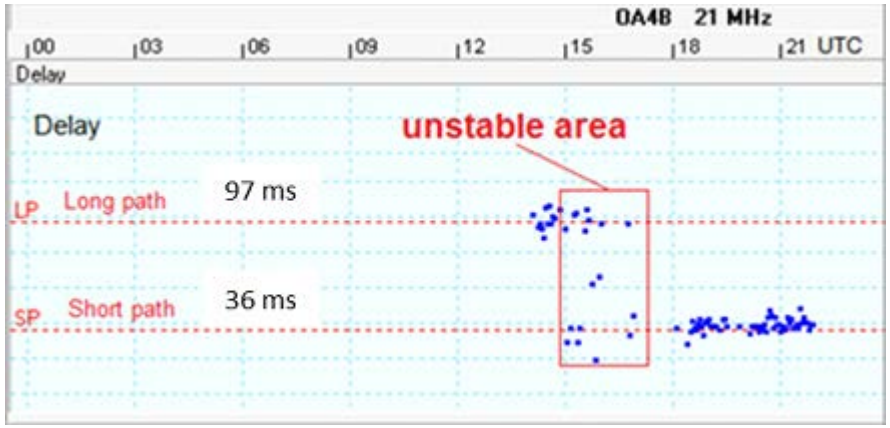


RBN and WSPRnet papers

- Frissell, et al, Ionospheric Sounding Using Real-Time Amateur Radio Reporting Networks, Space Weather 2014
- Frissell, et al, High-Frequency Communications Response to Solar Activity in September 2017 as Observed by Amateur Radio Networks, Space Weather 2019

Collaboration with Scientists

- IARU/NCDXF worldwide beacon network
- 18 transmitters on 20m, 17m, 15m, 12m, 10m



- Monitor with Faros software (VE3NEA)
- OA4B reception in Italy on June 4, 2014 on 21 MHz
- Also captures SNR
- In between long path and short path suggests a skewed path

Another Pop Quiz!

What is the technical term for how often you go to a restaurant to eat a Greek sandwich?

Areas of Interest Needing Research

- F2 region varies considerably on a day-to-day basis
- Solar radiation, geomagnetic field activity and events in the lower atmosphere coupling up to the ionosphere
  - See Rishbeth and Mendillo, Patterns of F2-layer variability, JASTP, 2001
- Result is we have a monthly median model of the ionosphere for propagation predictions – not a daily model
- Need to better understand the following
  - Geomagnetic field activity – STORM model is current
  - Events in lower atmosphere
    - When do they generate AGWs?
    - When do AGWs couple up to the ionosphere?
    - How is propagation affected?
    - What parameter(s) would represent this process?

Areas of Interest Needing Research

- D region
- Our understanding of the D region is based on rocket flights, incoherent scatter radar, analysis of lightning discharges at VLF and models involving complicated chemistry
- The D region is the driver of propagation on the lower bands – especially on 630m, 160m and 80m
- On one hand it would be good to understand all of this
- On the other hand, it might take the excitement and mystery out of QSOs on the low bands!

Summary

- Hams have contributed much to science
- Not only propagation – also radio design, antenna design, waveform design, etc
- I'm sure we'll continue contributing in the future