GEMSModels

Incorporating a high-level description of `lyr`

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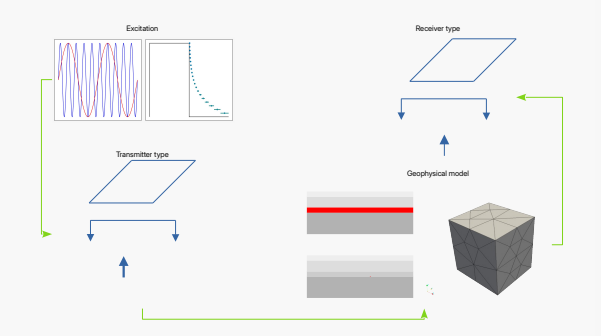
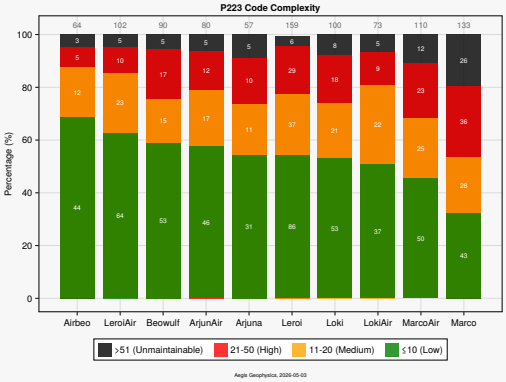
What is GEMSModels?

- GEMSModels is designed to model geophysical electromagnetic surveys to aid survey planing and data analysis and interpretation
- It is a modernised version of the CSIRO AMIRA P223 Suite (Raiche et al., 2007)
- When completed, GEMSModels will be able to model layered earth (lyr), thin plates hosted in layered earths (thn) and discretised volumes (vol)



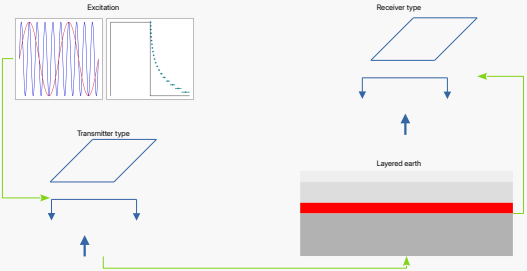
Why GEMSModels?

- The P223 Suite was developed at CSIRO with 27 years of industry support
- It was released to the public in 2008 when the program ended
  - It is unsupported and unmaintained
  - It is difficult to add capability required to model extant prospecting systems because of code complexity (McCabe, 1976)
- GEMSModels is designed to address maintenance and complexity issues
  - Completely rewritten in Julia
  - Focus on simplicity, clarity, reuse and ease of extension



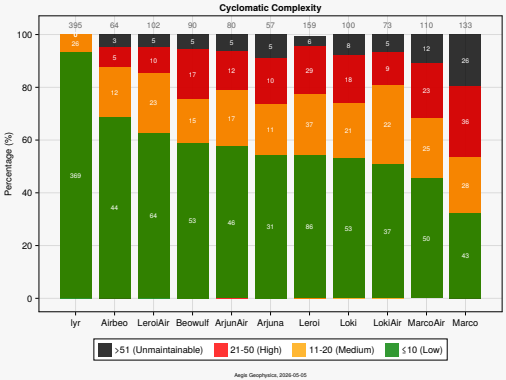
What is `lyr`?

- `lyr` is the first component of `GEMSModels`
- `lyr` models the forward and inverse response of geophysical TEM and FEM surveys over layered earths
- It combines capabilities of `Airbeo` and `Beowulf`



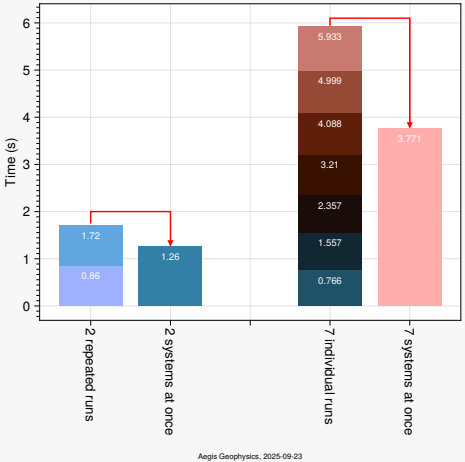
How does `lyr` improve on equivalents in the P223 Suite?

- `lyr` is significantly simpler than any code in the P223 Suite
- Simple and modular code will form the basis of `GEMSModels`
  - Simple code is easier to maintain
  - Extensive use of high-level types promotes clarity
  - Extensive use of high-level types permits easier extension for new capability



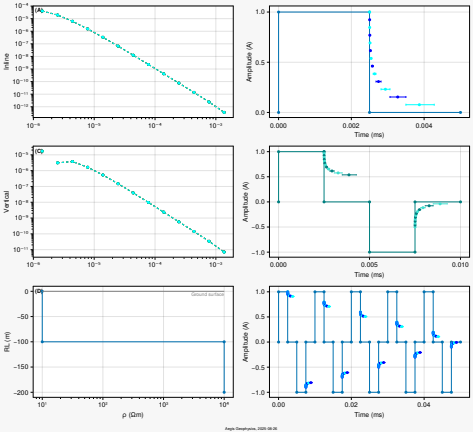
How does `lyr` improve on equivalents in the P223 Suite?

- `lyr` is able to model the response of multiple TEM excitations in a single run
  - This leads to efficiency gains in parametric studies for survey design
  - This permits modelling of multiple-moment waveforms



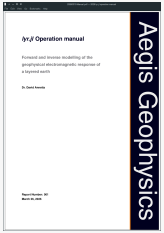
How does `lyr` improve on equivalents in the P223 Suite?

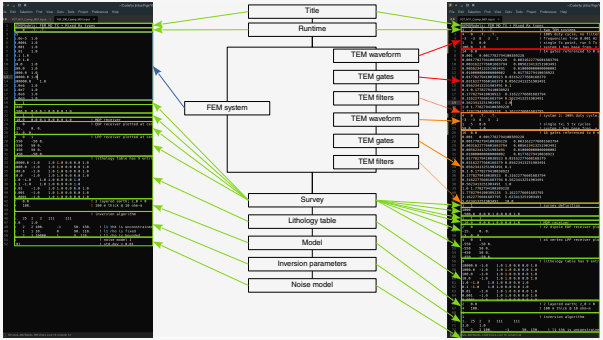
- `lyr` is easily able to model the effects of a variable number of transmitter cycles
  - Conductive earths typically require a greater number of transmitter cycles to be modelled in order to properly account for transmitter run-on effects
- `lyr` is able to model a fully-specified transmitter waveform (right)
  - Complex waveforms can be modelled by specifying the full cycle instead of the half-cycle



How does `lyr` improve on equivalents in the P223 Suite?

- `lyr` is documented
  - A logical input file can be written without reference to a long ASCII text





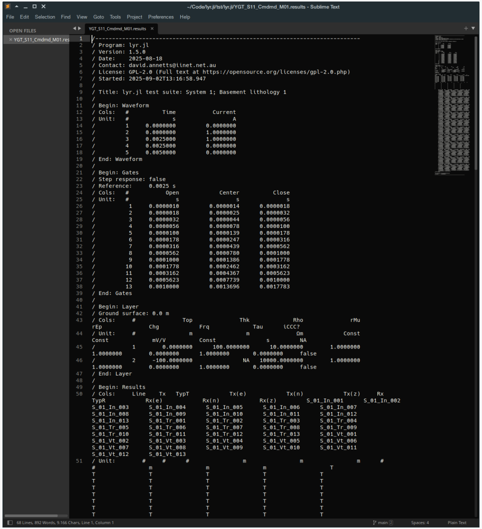
How does `lyr` improve on equivalents in the P223 Suite?

- `lyr` is driven from the command line
  - Inputs required by the program are derived by the program
  - Output file names are derived from the input file name

Extent	Type	Description
`input`	Input	Prospecting system, survey & model specification. This file is required for forward and inverse modelling.
`field`	Input	Field data to be inverted. This file is only read if the option to invert data is selected. It has the same format as the `results` file.
`noise`	Input	Detailed noise calculations for field data. This file is only read if the option to invert data is selected *and* noise model 3 is selected. This file is in exactly the same format as the `field` file. Indeed, it should have exactly the same number of lines and columns.
`details`	Output	Verbose program output. This file should be checked to ensure that what is modelled was what was intended to be modelled.
`results`	Output	Plotting output. This file is intended to be used for plotting. Although output data are columnar & ASCII, metadata are provided so that sophisticated programs are able to use a single file to reproduce all data associated with the output such as transmitter waveforms and any model.
`summary`	Output	This file contains a summary of the run – essentially a screen dump

How does `lyr` improve on equivalents in the P223 Suite?

- `lyr` output is opinionated
  - All program outputs are always output and always in the same order
- Output is designed to be read and filtered by an application
  - Extensive metadata are provided in comments




```
/-----------------------------------------------------------------------------
/ Program: lyr.jl
/ Version: 1.5.0
/ Date:    2025-08-18
/ Contact: david.annetts@iinet.net.au
/ License: GPL-2.0 (Full text at https://opensource.org/licenses/gpl-2.0.php)
/ Started: 2025-09-02T13:16:58.947
/
/ Title: lyr.jl test suite: System 1; Basement lithology 1
/
/ Begin: Waveform
/ Cols:   #          Time           Current
/ Unit:   #             s                 A
/         1     0.0000000         0.0000000
/         2     0.0000000         1.0000000
/         3     0.0025000         1.0000000
/         4     0.0025000         0.0000000
/         5     0.0050000         0.0000000
/ End: Waveform
/
/ Begin: Gates
/ Step response: false
/ Reference:     0.0025 s
/ Cols:   #          Open            Center           Close
/ Unit:   #             s                 s               s
/          1     0.0000010         0.0000014       0.0000018
/          2     0.0000018         0.0000025       0.0000032
/          3     0.0000032         0.0000044       0.0000056
/          4     0.0000056         0.0000078       0.0000100
/          5     0.0000100         0.0000139       0.0000178
/          6     0.0000178         0.0000247       0.0000316
/          7     0.0000316         0.0000439       0.0000562
/          8     0.0000562         0.0000780       0.0001000
/          9     0.0001000         0.0001386       0.0001778
/         10     0.0001778         0.0002462       0.0003162
/         11     0.0003162         0.0004367       0.0005623
/         12     0.0005623         0.0007739       0.0010000
/         13     0.0010000         0.0013696       0.0017783
/ End: Gates
/
/ Begin: Layer
/ Ground surface: 0.0 m
/ Cols:     #              Top              Thk              Rho              rMu
rEp              Chg              Frq              Tau       iCCC?
/ Unit:     #                m                m               Ωm            Const
Const           mV/V             Const               s          NA
/           1        0.0000000      100.0000000      10.0000000        1.0000000
1.0000000        0.0000000      1.0000000       0.0000000     false
/           2     -100.0000000               NA   10000.0000000       1.0000000
1.0000000        0.0000000      1.0000000       0.0000000     false
/ End: Layer
/
/ Begin: Results
/ Cols:     Line    Tx   TypT            Tx(e)            Tx(n)            Tx(z)     Rx
TypR            Rx(e)            Rx(n)            Rx(z)        S_01_In_001      S_01_In_002
S_01_In_003      S_01_In_004      S_01_In_005      S_01_In_006      S_01_In_007
S_01_In_008      S_01_In_009      S_01_In_010      S_01_In_011      S_01_In_012
S_01_In_013      S_01_Tr_001      S_01_Tr_002      S_01_Tr_003      S_01_Tr_004
S_01_Tr_005      S_01_Tr_006      S_01_Tr_007      S_01_Tr_008      S_01_Tr_009
S_01_Tr_010      S_01_Tr_011      S_01_Tr_012      S_01_Tr_013      S_01_Vt_001
S_01_Vt_002      S_01_Vt_003      S_01_Vt_004      S_01_Vt_005      S_01_Vt_006
S_01_Vt_007      S_01_Vt_008      S_01_Vt_009      S_01_Vt_010      S_01_Vt_011
S_01_Vt_012      S_01_Vt_013
/ Unit:         #     #      #                m                m                m      #
#                m                m                m                T
T                T                T                T                T
T                T                T                T                T
T                T                T                T                T
T                T                T                T                T
T                T                T                T                T
T                T                T                T                T
T                T                T                T                T
```

Summary

- `lyr`, the first component of `GEMSModels`, is a significant improvement on P223 Suite capability
  - Simpler code allows maintenance, easier extension and greater consistency with other components of the suite
  - Clearer output allows more consistent processing and analysis
  - Better documentation allows focus on the survey and how to model it
  - More capability smooths the path towards the end goals of survey design and data analysis

References

McCabe, T.. 1976. A Complexity Measure. *IEEE Transactions on Software Engineering* SE-2, 308–320.
Raiche, A., G. Wilson, and F. Sugeng. 2007. Practical 3D inversion – The P223F Software Suite. ASEG. Perth, WA, 68–69.

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