Common Development Model (CDM) 06 Turboprop 00 (TP00)

UNCLASSIFIED / Non-Proprietary

Generic NPSS Turboprop

Originally provided by J. Tai of Georgia Tech

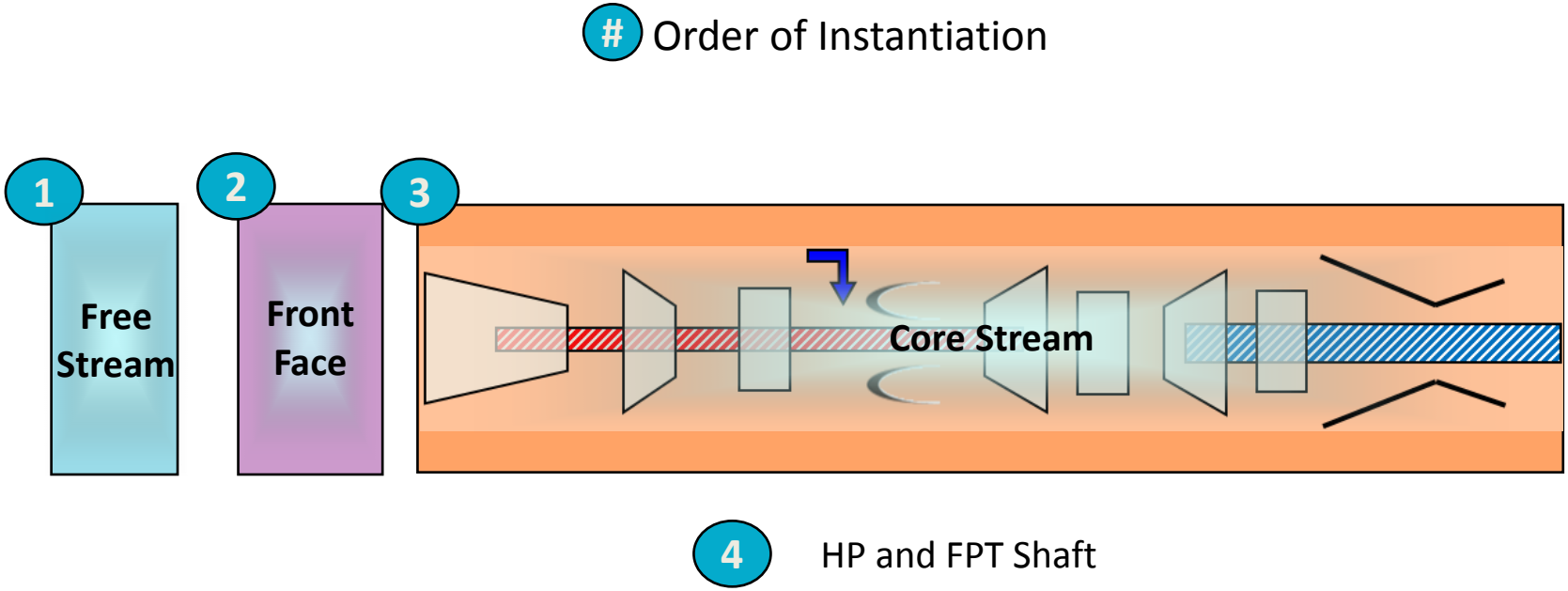
Outline

- File Directory Structure
- Model Structure
  - Components
- Steady-State Running
  - Design
  - Off-Design

File Directory Structure

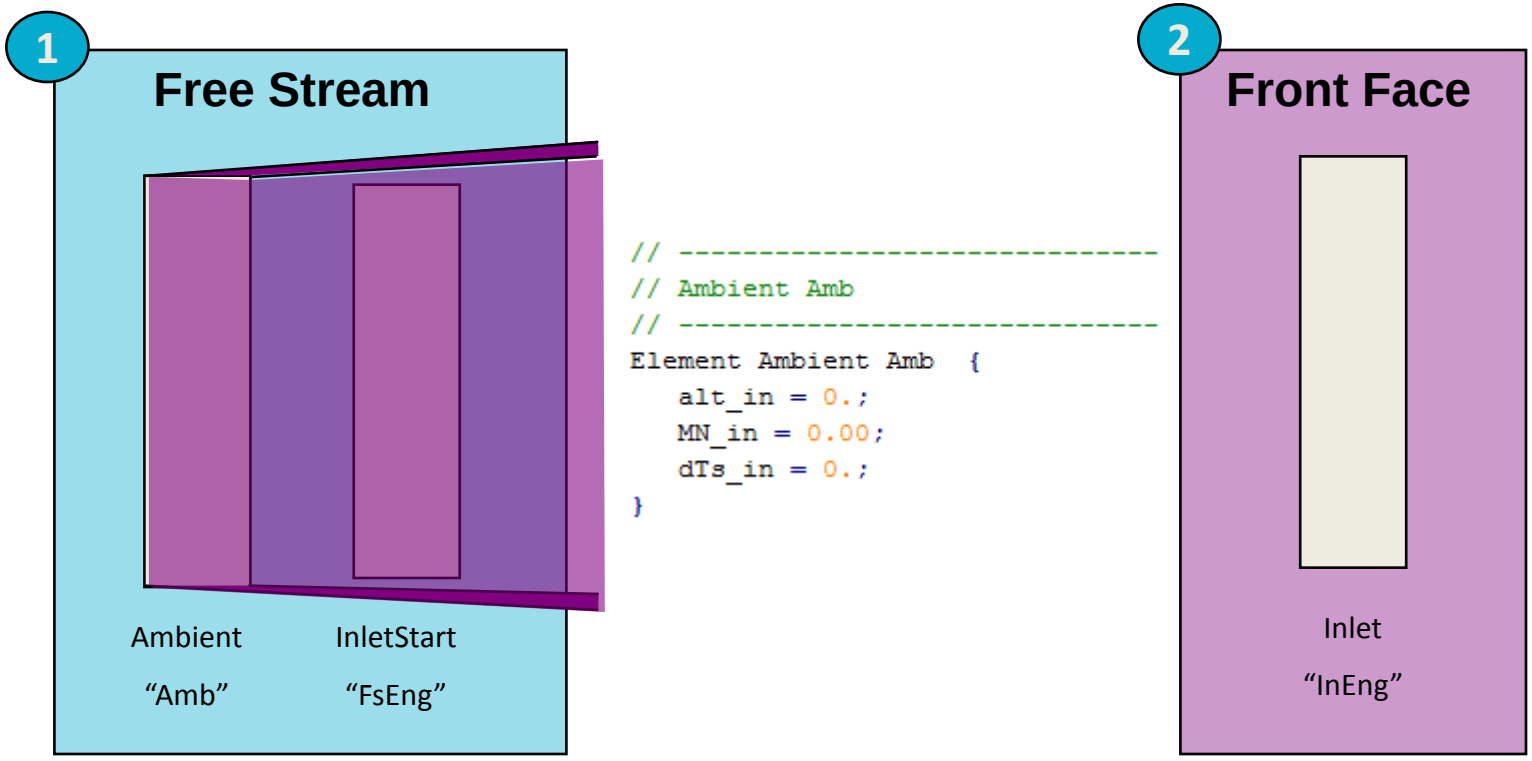
- Following the SAE recommended practices in ARP5571, the following directory structure is implemented
  - /src
    - Source directory including .int and .fnc files.
  - /data
    - Data directory including .inp, .map, .tabl, and .view files.
  - /check
    - Checkout information; sample .run file, test case input and output files.
  - /model
    - Source, compiled objects, and data, including all input required to build a complete model
  - /info
    - Model setup and usage documents, such as: README files, and any reference output files

Model Structure: Components



Expanded views of each group are presented in the following slides

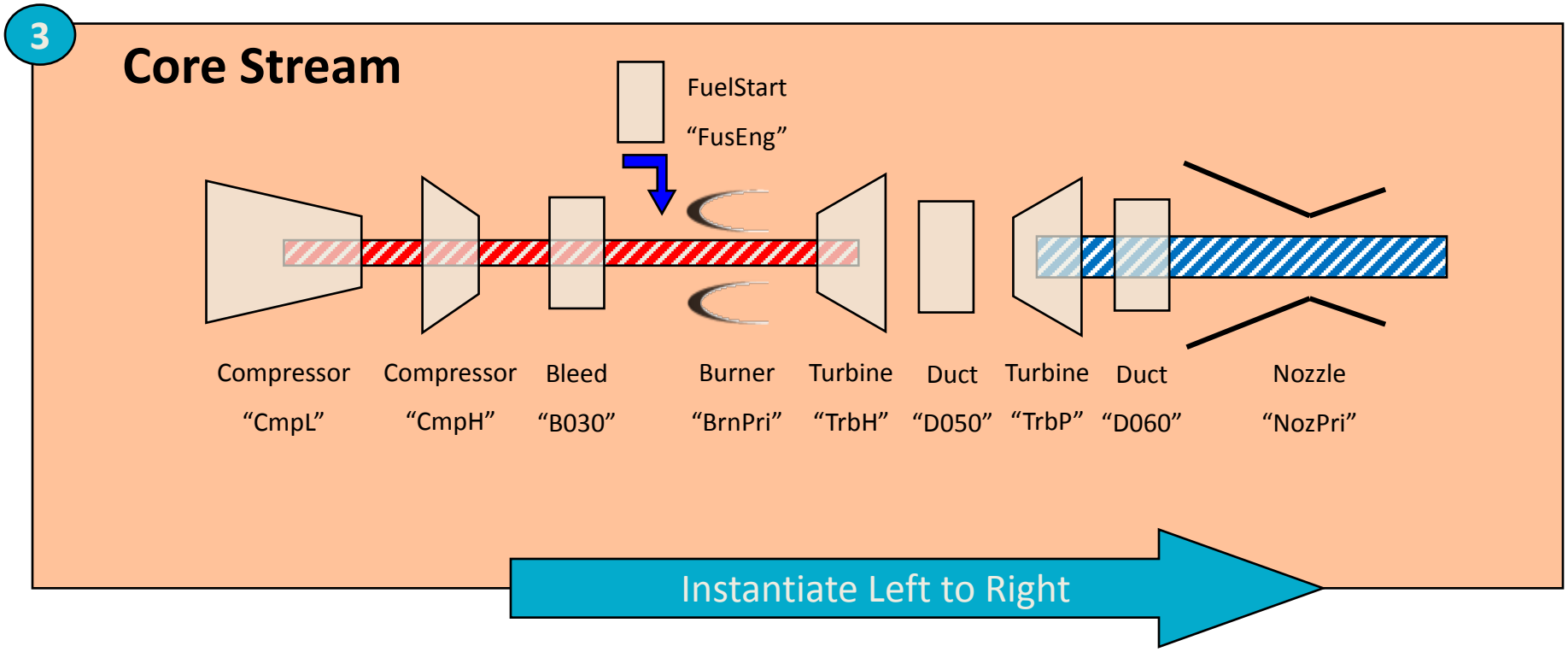
Model Structure: Components

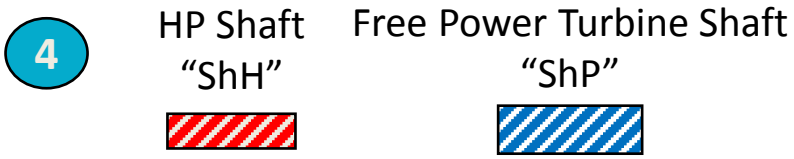



```
// -------------------------------
// Ambient Amb
// -------------------------------
Element Ambient Amb  {
   alt_in = 0.;
   MN_in = 0.00;
   dTs_in = 0.;
}
```

Instantiate Left to Right

Model Structure: Components





Design Point

- Base Model Run File: `cdm06_tf00.run`
- Model instantiation provides the following design point
  - Sea level ambient conditions at rest
  - Requires free power turbine shaft horse power of 1708 hp
  - Demands inlet temperature to free power turbine at 820°C
- Output saved to `cdm06_tp00.out`

```
Date:12/05/16    Time:11:57:28    Model:            cdm06_tp00    mode:    DESIGN   converge = 1   CASE:   1
Version:           NPSS_2.8    Gas Package:GasTbl    iter/pass/Jacb/Broy=173/198/ 5/--    Run by:          acostanzo


                                        SUMMARY OUTPUT DATA
    MN       alt     dTamb      VTAS         N1         N2         NP        T41       ITTC       SHP       THP      ESHP      BSFC      ESFC
 0.000       0.0      0.00      0.00    37500.0    30000.0    2000.00    2516.34     820.00   1708.00    152.20   1860.20     0.534     0.490


                                        FLOW STATION DATA
                                  W         Pt         Tt         ht        FAR         Wc         Ps         Ts       Aphy         MN       gamt         Rt
F010 FsEng.Fl_O             11.68     14.696     518.67     123.95     0.0000      11.68     14.696     518.67    ------.-     0.0000    1.40052    0.06856
F020 InEng.Fl_O             11.68     14.696     518.67     123.95     0.0000      11.68     12.388     493.92       45.6     0.5000    1.40052    0.06856
F029 CmpL.Fl_O              11.68     54.375     800.35     191.90     0.0000       3.92     48.726     775.98       18.2     0.4000    1.39193    0.06856
F030 CmpH.Fl_O              11.68    161.494    1131.81     274.01     0.0000       1.57    151.896    1113.11        9.4     0.3000    1.37244    0.06856
F031 B030.Fl_O              10.67    161.494    1131.81     274.01     0.0000       1.43    144.922    1098.94        6.7     0.4000    1.37244    0.06856
F040 BrnPri.Fl_O            10.93    150.189    2582.06     689.95     0.0237       2.39    149.220    2578.25       42.1     0.1000    1.29577    0.06854
F045 TrbH.Fl_O              11.93     47.687    1967.67     507.96     0.0217       7.16     44.964    1940.18       43.7     0.3000    1.31417    0.06855
F050 D050.Fl_O              11.93     47.210    1967.67     507.96     0.0217       7.24     44.514    1940.18       44.2     0.3000    1.31417    0.06855
F060 TrbP.Fl_O              11.93     18.392    1608.53     406.79     0.0217      16.79     16.968    1576.58       89.0     0.3500    1.32983    0.06855
F070 D060.Fl_O              11.93     17.932    1608.53     406.79     0.0217      17.22     16.899    1584.95      104.6     0.3000    1.32983    0.06855
F090 NozPri.Fl_O            11.93     17.932    1608.53     406.79     0.0217      17.22     14.696    1530.57       64.0     0.5536    1.32983    0.06855

TURBOMACHINERY PERFORMANCE DATA
                    Wc       PR       eff        TR  effPoly        pwr      SMN      SMW      s_Re
CmpL             11.68    3.700    0.8300    1.5431   0.8577    -1122.9    13.96    19.91   1.00000
CmpH              3.92    2.970    0.8500    1.4141   0.8704    -1357.0    56.98    30.37   1.00000
TrbH              2.39    3.149    0.8800    1.2591   0.8647     2479.9
TrbP              7.24    2.567    0.8900    1.2233   0.8782     1708.0

TURBOMACHINERY MAP DATA
                  WcMap    PRmap    effMap     NcMap    R/Parm    s_WcDes   s_PRdes  s_effDes   s_NcDes
CmpL              71.45    5.397    0.8223     1.000    2.0000     0.1635    0.6141    1.0094  ---.----
CmpH               2.72    2.300    0.8400     1.000    2.0000     1.4417    1.5154    1.0119  ---.----
TrbH              10.14    6.000    0.8998   100.000    6.0000     0.3644    0.4299    0.9780    7.3799
TrbP              35.30    6.000    0.9231   100.000    6.0000     0.3177    0.3134    0.9641    6.7631
```

Off-Design Points

- Off-design mode is activated with `setOption("switchDes", "OFFDESIGN")`
- Off-Design Cases 2-8:
  - Case 2: Prop speed set to 2000 rpm; free turbine shaft horsepower still set to 1708 hp
  - Case 3: Free turbine shaft horsepower increased to 1800 hp
  - Case 4: Ambient inlet temperature set to 36°C for a "hot day"
  - Case 5: Ambient inlet altitude set to 12,000 ft. (critical altitude); ambient inlet temperature set back to 0°C
  - Case 6: Free turbine shaft horsepower set to 1250 hp; ambient altitude set back to sea level
  - Case 7: Free turbine shaft horsepower set to 1100 hp
  - Case 8: Ambient inlet temperature set to 36°C
- All results printed to output file: `cdm06_tp00.out`