Outline for Class Project Written Report
– Due March 20th

- Total report length: 5 to 10 pages. You may go longer if you think more pages will add to the quality of the content. (Reports will be graded on contents rather than length.)

1. Science Goals

a) Describe scientific context and background
b) Statement of your <u>specific</u> science goals, with scientific motivation
    i. What question(s) will you address?
    ii. Why are they interesting and/or important?
c) What measurements/observations will you make with new AO system / instrument?
d) How will your measurements/observations help answer your science question(s)?

2. Science Requirements (these will vary with your specific science cases)

Examples of possible science requirements to consider:

a) What sample will your targets be drawn from? How many potential targets are there per square arc minute? What magnitude are they? (These items will be determinants of your sky coverage fraction.) Are they point-sources so that they can be used as guide stars or tip-tilt stars, or will you need a separate natural guide star, or a laser guide star plus tip-tilt star?
b) What will be your observing wavelengths, and why?
c) What size telescope are you planning to use?
d) Will you be using natural guide stars or laser guide stars?
e) For exoplanet detection and imaging of circumstellar material: what is the required intensity contrast between the star and the planet/circumstellar material, and at what distance from the parent star (in AU and in arc sec)?
f) Will you do imaging or spectroscopy? In both cases, what spatial resolution is needed, and why? If spectroscopy, what spectral resolution will you need, and why?
g) What will be the science instrument behind the AO system? Does it already exist, or will you "build" a new instrument? What should its general characteristics be? (imager, slit spectrograph, integral field spectrograph = a spectrum at every image pixel, other).
h) What observing site will you use? This will determine r0, for example.

3. Performance Requirements for AO system, telescope, and back-end instrument

a) For imaging applications: from the spatial resolution and observing wavelength described in Section 2, what range of Strehl ratios (at what wavelengths) will be acceptable for your science goals?
b) For spectroscopy and photometry applications: what range of enclosed energy (the fraction of energy enclosed within a circle of radius xxx arc sec) will you need to accomplish your science goals?
c) At what sky coverage fraction will the two requirements above need to be met? In other words, over what areal fraction of the sky will you need to achieve a Strehl ratio of at least yyy, or an enclosed energy fraction of at least zzz, in order to observe a meaningful statistical sample of your target objects?

4. AO system, instrument, and telescope concepts

a) Rough Estimate: The next task is to estimate the broad specifications of the hardware: how many actuators does your deformable mirror need, and hence how many subapertures on your wavefront sensor? This is tightly coupled with which telescope you plan to use - an existing 3-4m telescope, an existing 8-10m telescope, or a future 20-30m "Extremely Large Telescope". At this stage, make your zero'th-order estimate considering only fitting error and WFS measurement error, taking into account that if you add more and more subapertures, the SNR of the WFS measurement within one subaperture will go down (unless you restrict yourself to brighter and brighter natural guide stars or unless you keep increasing the power of your laser guide stars).

b) Error Budget: Once you have decided on an order-of-magnitude estimate for the number of subapertures and actuators, you will need to make an error budget. This will help you to narrow down to a set of AO and telescope parameters that will give you the performance you specified in Section 3. You can use the Error Budget Spreadsheet that I sent around, or if you prefer, you can make your own error budget using the equations from our class lectures and readings. Or you can use a combination of both. The goal is to end up with the approximate specifications for your wavefront sensor and deformable mirror, for the WFS sampling rate (and hence for the closed-loop bandwidth), for how bright a natural guide star or tip-tilt star you will need, and for the laser power and spot size, etc. The output for your preferred design will be the Strehl ratio, enclosed energy fraction, and/or contrast ratio assuming an on-axis guide star or tip-tilt star, and also (if relevant) for off-axis guide stars or tip-tilt stars as a function of the sky coverage fraction (as guide stars get fainter, there will me more and more of them per square arc minute, and hence the sky coverage fraction will be larger).

c) Supporting Data: the spreadsheet contains seeing data (r0, CN2 profiles, tip-tilt star density) which you can use to answer the questions in part b) above.

5. Bonus Items:

a) Acronym for your AO system and instrument
b) Logo for your AO system and instrument
c) Your roles: Principle Investigator (PI), Project Scientist, Project Manager
d) Observing plan/how data will be gathered
e) Plan for data reduction/pipeline
f) Project timeline
g) A wild guess at the total project cost