Procedure for Implementing Hourly CPS :

PURPOSE :

1. The Hourly Control Performance Standard (CPS-60) is intended to provide a second control point on the statistically bounded frequency error envelope[1] around scheduled frequency, thus replacing the existing CPS2 measurement.
2. By utilizing a longer averaging period than CPS1, CPS-60 compliance provides a bound on system frequency in a time frame that is both commercially significant (almost all commercial transactions are based on hourly MWh measurements) and critical to system reliability (due to the large number of transactions beginning or terminating on an hourly basis).
3. At the same time, the one hour averaging period of CPS-60 allows system users to take maximum advantage of the natural diversity available across the various interconnections consistent with the requirements of reliable system operations.
4. The proposed one month compliance period for CPS-60 also provides Balancing Authority operators with frequent feedback regarding their impact on system frequency performance that is relatively easy to calculate each hour and will provide near real time performance information for the Balancing Authority operators and Reliability Authorities.

DEFINITION OF HOURLY CPS :

5. Hourly CPS (CPS-60) is calculated in a manner similar to CPS1, but for a longer (sixty minute) averaging period and a different target average frequency (ε_{60}).
6. As with CPS1, CPS-60 is calculated by multiplying the Balancing Authority ACE times the frequency error and dividing by minus ten times the Balancing Authority Frequency Bias (F_B). . Unlike CPS1, however, the average ACE and frequency error used for CPS-60 are calculated over a one hour (sixty minute) period.
7. Compliance with CPS-60 is measured with respect to the square of the target Interconnection hourly average frequency error, ε_{60}. I estimate that

[1] The allowable frequency error envelope is sometimes called the Jaleeli Curve in honor of Nasser Jaleeli, its developer. See N. Jaleeli and L. S. VanSlyck, *Control Performance Standards and Procedures for Interconnected Operation*, EPRI TR-107813, Electric Power Research Institute, Palo Alto, CA, April 1997
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ε_{60} will be approximately 0.004 Hz. (4 mHz.) for the Eastern Interconnection.

8. The inequality equation for CPS-60 thus becomes :

$$AVG_{Period}(ACE_{60} * \Delta F_{60})/(-10F_B) \le \varepsilon_{60} \text{ or } AVG_{Period}(ACE_{60} * \Delta F_{60})/(-10F_B * \varepsilon_{60}) \le 1$$

Where :

AVG_{Period} is the average for the period over which CPS-60 is being evaluated

ACE_{60} is the clock hour average of the Balancing Authority ACE

$-10F_B$ is the frequency bias of the Balancing Authority. For those Balancing Authorities using variable bias, $-10F_B$ should be averaged for the hour in a manner similar to ACE

ε_{60} is a constant derived from the targeted frequency bound of the Interconnection. It is the targeted RMS of one hour average frequency error based on frequency performance over a given year. The bound is the same for every Balancing Authority within an Interconnection

ΔF_{60} is the clock hour average of frequency error. ΔF is calculated as $\Delta F = F_A - F_S$, where F_A is the actual (measured) frequency and F_S is scheduled frequency for the Interconnection,

COMPLIANCE :

9. The compliance requirements for CPS-60 consists of two components :
   a. A monthly average CPS-60 compliance requirements effectively bounds the long term average Interconnection frequency limits in the same manner as CPS1. I propose that the same compliance limits used for CPS1 be adopted for CPS-60
   b. A compliance requirement based on the number and magnitude of severe violations bounds the impact that any individual Balancing Authority may have on the Interconnection as a whole. A compliance envelope based on the number and magnitude of violations should be developed to work in conjunction with the monthly average compliance limit.
10. Monthly average CPS-60 compliance is calculated in the same manner as CPS1, but on a sixty minute averaging basis. Specific compliance calculations are as follows :
    a. CPS-60 compliance is calculated using a Compliance Factor, CF-60, as follows :

       CPS-60 = (2 – CF-60)*100%

b. CF-60 is a ratio of the average of the hourly compliance factors (CF_{60}) calculated for the month divided by the Hourly Average Targeted Frequency Bound :

$CF\text{-}60 = \Sigma CF_{60}/n * \varepsilon_{60}^2$

Where :

$\Sigma CF_{60}/n$ is the average (for the n hours of the month) of the hourly Compliance Factor, CF_{60}

ε_{60} is the Hourly Average Targeted Frequency Bound for the Interconnection

c. The hourly Compliance Factor (CF_{60}) is calculated for each hour as follows :

$CF_{60} = ACE_{60} * \Delta F_{60} / -10F_B$

Where :

ACE_{60} is the average Balancing Area ACE for the hour

ΔF_{60} is the average Balancing Area frequency error for the hour

$-10F_B$ is the Balancing Area frequency bias. For Balancing Areas using variable frequency bias this would be the average Balancing Area frequency bias for the hour.

Note that the one minute average ACE and Frequency Error data currently being collected for CPS1 can be utilized to calculate ACE_{60} and ΔF_{60}.

11. The CPS-60 compliance based on the number and magnitude of severe violations is calculated using a Darnit Factor (DF). A "darnit[2]" is earned any time CF_{60} exceeds ε_{60}^2. Additional "darnits" are earned based on the ratio of CF_{60} to ε_{60}^2, thus the hourly Darnit Factor (DF_{60}) is :

$$DF_{60} = \left\{ CF_{60} < \varepsilon_{60}^2, 0 : CF_{60} \geq \varepsilon_{60}^2, CF_{60} / \varepsilon_{60}^2 \right\}$$

Where :

CF_{60} is the hourly Compliance Factor as calculated above

ε_{60} is the Hourly Average Targeted Frequency Bound for the Interconnection

Note that DF_{60} is zero unless CF_{60} equals or exceeds ε_{60}^2.

a. Balancing Authority compliance is based on the monthly sum of the hourly Darnit Factors (ΣDF_{60}).

[2] Terry Bilke of MISO, a member the NERC Resources Subcommittee, is responsible for much of the initial research on a short term CPS compliance factor. According to Terry, system operators typically say "Darn it!" when they have a compliance problem. All I can say is Terry's operators are much more polite than mine.

b. While CPS theory bounds the impact that any individual Balancing Authority may have on the average frequency of its Interconnection, the statistically bounded frequency error envelope around scheduled frequency does not limit the magnitude short term frequency excursions (which can be though of as outliers on the tail of the frequency error distribution).
c. Setting a limit on the monthly DF for a Balancing Authority limits the impact which that Balancing Authority may have on the Interconnection and stay within compliance.
d. There is a limited amount of data on which to base initial DF limits for a Balancing Authority. However, I recommend that the initial settings be developed as part of the field trial for the CPS-60 standard. A "gut feel" compliance requirement would be :

Level 1	DF > 15
Level 2	DF > 30
Level 3	DF > 45
Level 4	DF > 60

12. Using the CPS1 limits for average monthly CPS-60 and the "gut feel" levels for the severe violation (DF) component, the overall compliance requirements for CPS-60 becomes :

	Average CPS-60		DF
Level 1	95.0 to 99.9	or	>15
Level 2	90.0 to 94.9	or	>30
Level 3	85.0 to 89.9	or	>45
Level 4	84.9 or less	or	>60

ISSUES :

13. Targeted research will be needed to determine a number of parameters associated with CPS-60. These include :
a. The value of ε_{60} will need to be established definitively. While ε_1 and ε_{10} were established in the initial study, no hourly value was calculated that I know of.
b. DF limits will need to be established for the definitively Balancing Authorities. While my initial idea is that a single set of limits may be used for all Balancing Authorities, it may be better to vary the DF limits with the size of the Balancing Authorities in a manner similar to L_{10}. This logic needs to be further explored.
c. The economic and reliability impacts of migrating from the current CPS/DCS methodology to CMP1, CMP-60 and DCM should be

explored. While I think that the proposed metrics will improve reliability while holding regulation costs steady or driving them lower I can not prove this assertion. This logic needs to be further explored.

d. While I think that this proposed measure will have the characteristics noted above, my math is not good enough to prove it from the base CPS theory. Someone with much stronger math abilities than I needs to review this proposal to make sure that it is consistent with the original CPS theory proposed by Jaleeli and Van Slyck.

14. The commercial implications of CPS-60 also need to be explored. While intended solely as a reliability measure, CPS-60 corresponds to the one hour energy time frame and may provide a framework for quality assurance in commercial transactions. That is, there is a potential that contracts will be written using CPS-60 for a performance measure and that energy prices will be discounted if CPS-60 is outside some acceptable limit. It is not at all clear what, if any, impact this will have on system reliability, but it would seem likely to reinforce any penalty associated with CPS-60 non-compliance.