TVS Extragalactic Transients Summary Report on Cadences v2.0 and v2.1

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Science metrics were developed to quantify the impact of new simulated survey strategies on a number of transient science cases. Plots to assess the metrics can be generated based on the jupyter notebook at these links:

https://github.com/lsst-pst/survey_strategy/blob/main/fbs_2.0/Demo_TVSMetrics.ipynb
https://github.com/lsst-pst/survey_strategy/blob/main/fbs_2.0/Rolling%20Cadence.ipynb

The primary metrics used to evaluate the impact of survey strategy on TVS Extragalactic Transients science cases are presented in the table at the end of this document.

The results were interpreted by TVS members, helped by L. Jones. In summary:

- **A non-rolling cadence would negatively affect all transient science**, typically by 20%. Continuing the point of rolling in at least 2 bands and at strength 90% (which is the current v.2.0 baseline), or, for most science cases, adopting even stronger rolling cadences is recommended.

- Stronger rolling (ns=3 and/or rw=0.8 or 0.9) is preferred by kilonova metrics that add classification requirements (ztfrest_simple and PrestoKNe, with improvements of ~10%), as well as for supernova metrics for early photometric classification (especially for core-collapse supernovae, SNRatemetric shows 2% higher performances for these strong rolling cadences). On the other hand, stronger rolling starts to do a poorer job for tidal disruption events metrics (TDE; see also the bullet below and Gezari+2018). This holds true whether the rolling is only low-dust WFD, also in the bulge, or all-sky.

- For TDEs, a strong rolling cadence will have a negative impact. The large majority of TDE light curves have a ~10 year long plateau phase (during which the flux is almost constant at M=-17). Detecting this late-time emission is extremely valuable for photometric classification (SNe never show such long-lived plateaus), plus these plateaus allow a black hole mass measurements. To make this possible, we need sufficient photometric coverage in the seasons after the main “rolling season”. For this reason, strong 3-band or 6-band rolling cadence is disfavored. This is not reflected in the current metric output, since these only focus on early classification (first 100 days).

- 6-band rolling can boost fast transient discovery and classification by ~25% (*six_rolling_ns6_rw0.9_v2.0_10yrs* cadence). L. Jones is concerned that 6-band rolling cadence may be more fragile to weather downtime, as each 'band' is only in an active season phase once over the lifetime of the survey; a season of bad weather will have a large impact on the final depths in that part of the sky.

❖ On the topic of the u-band exposure time, we can give a general recommendation (as requested in the Community post) for long-duration transients: If a longer u-band exposure time is selected, this should not reduce the total number of u-band epochs of the full survey. Fewer epochs are detrimental for photometric classification of SNe and TDEs. We note that u-band transient science is relatively unexplored, as such, a decrease of u-band epoch would also reduce the discovery potential of The Unknown, which is one of the key science pillars of Rubin. On the other hand, u-band observations are irrelevant/discouraged for serendipitous discovery of fast transients which are red in color (like kilonovae) and/or distant in the WFD survey, because of the low sensitivity of the filter and the intrinsically rapid evolution of transients in u-band compared to gri optical bands.

❖ "**Rolling early**" helps some kilonova metrics and some other metrics by up to 10%-15%, without a similar negative impact for the TDE metric. Communication with DESC is particularly encouraged on this, as they may have some preference for this based on on-sky uniformity at data release points. This cadence is similar to gaining additional time in rolling, at the cost of the first and last "uniform" seasons.

❖ **"Presto"** cadences, where intra-night revisits in at least one band are envisioned, can be of high impact (up to 30% for the *presto_gap4.0_v2.0_10yrs* with the ztfrest_simple and 20% in with the PrestoKNe metrics) to **discover** fast transients only if there is enough time spacing (> 3hr, with 4hr yielding the best results) between same-night visits in the same band. The larger the time gap, the better, confirming the recommendation made in the original Presto Color paper of gaps >2hr (Bianco+2019). Presto strategies with short time gaps are not recommended, as they perform worse than the baseline cadence. For slower timescale transients (i.e., TDE and most SN), the presto cadence can have a strong negative impact (200% to 50%, from short to long gaps), because the requirement of intra-night observations reduces the number of sources that have multi-band detections throughout their long-lived light curve. This negatively impacts by 5% also the classification performance for CC SNe that benefit from color evolution information to be correctly classified.

❖ The **long_gap** cadences typically bring advantages up to 10% over the baseline cadence for fast transient identification, with a peak 20% and 25% improvement when the *long_gaps_nightsoff0_delayed-1_v2.0_10yrs* and *long_gaps_np_nightsoff0_delayed-1_v2.0_10yrs* cadences are used. The "**suppress repeats**" family, in which triplets are spread across 3 consecutive nights, yielded a consistently positive improvement (from 15% up to 40%) for the ztfrest_simple fast transient metric, which relies on recognizing a significant magnitude change taking photometric uncertainties into account. This is in line with the recommendations for a nightly cadence outlined by Andreoni+2019. Other fast transient metrics and long-duration transient metrics are not affected by this type of repeats, or are damaged by up to 10%.

The metrics that we used to evaluate relevant extragalactic transient science cases are:

Total detected KNePopMetric__ztfrest_simple UserPointsSlicer' (for GW170817-like models)	How many KNe can be detected and identified as fast transients? (Igor & Michael)
Sum PrestoKNe__scoreS UserPointsSlicer	How many KNe can be detected and identified, evaluated using PLaSTiCC probabilities (Ming & Fed)
Total detected TDEsPopMetric__some_color_pu UserPointsSlicer	How many TDEs detected with a post-peak color measurement that includes u?
Total detected TDEsPopMetric_some_color UserPointsSlicer	How many TDEs can be detected with a post-peak color measurement (no u-band requirement). Note that this can be used for general extra-galactic science for slower blue transients (~10 day timescales).
SnRateMetric	How many supernovae are detected and classified with more than 5 data points within 30 days from the onset, which can enable photometric classification? (Fabio)