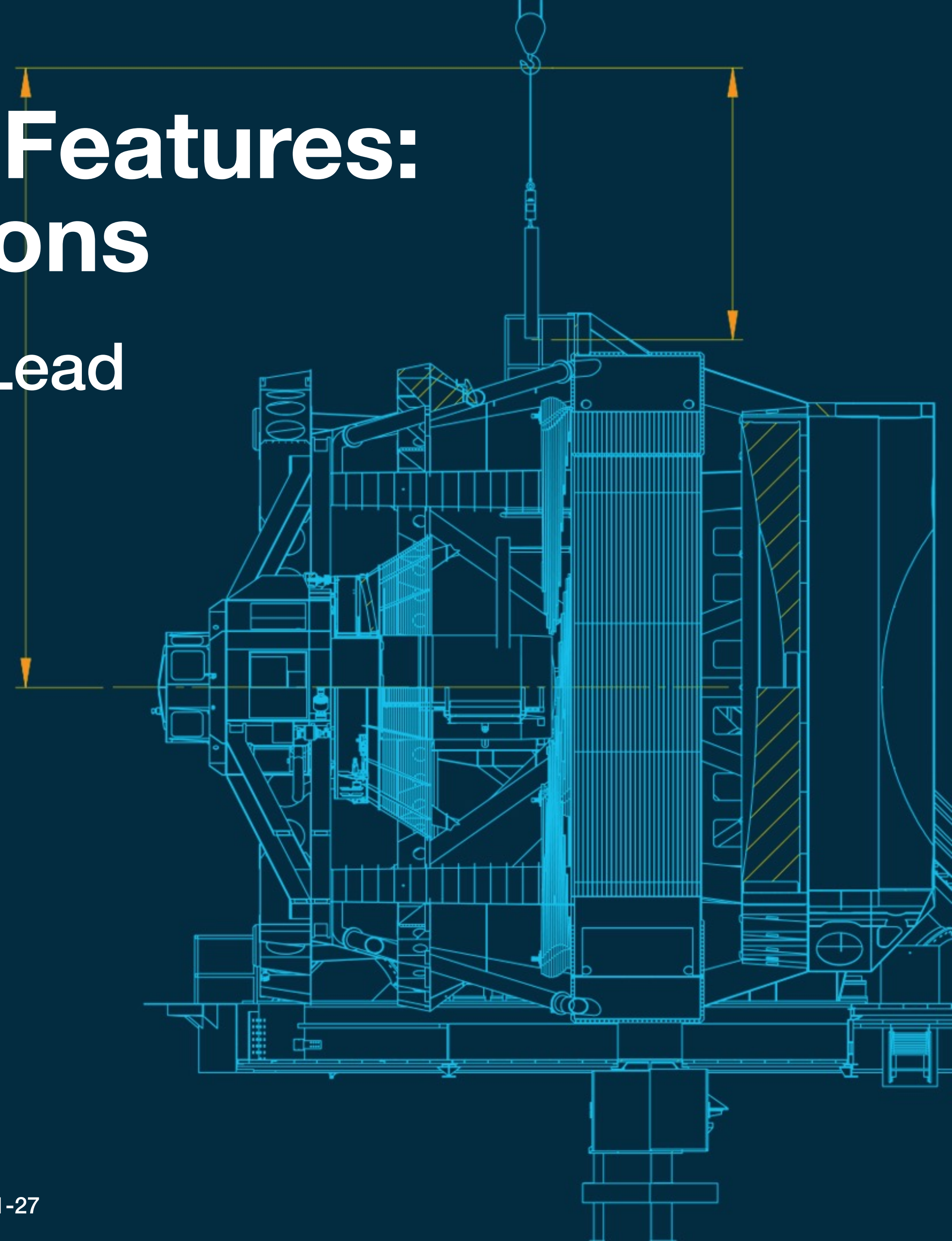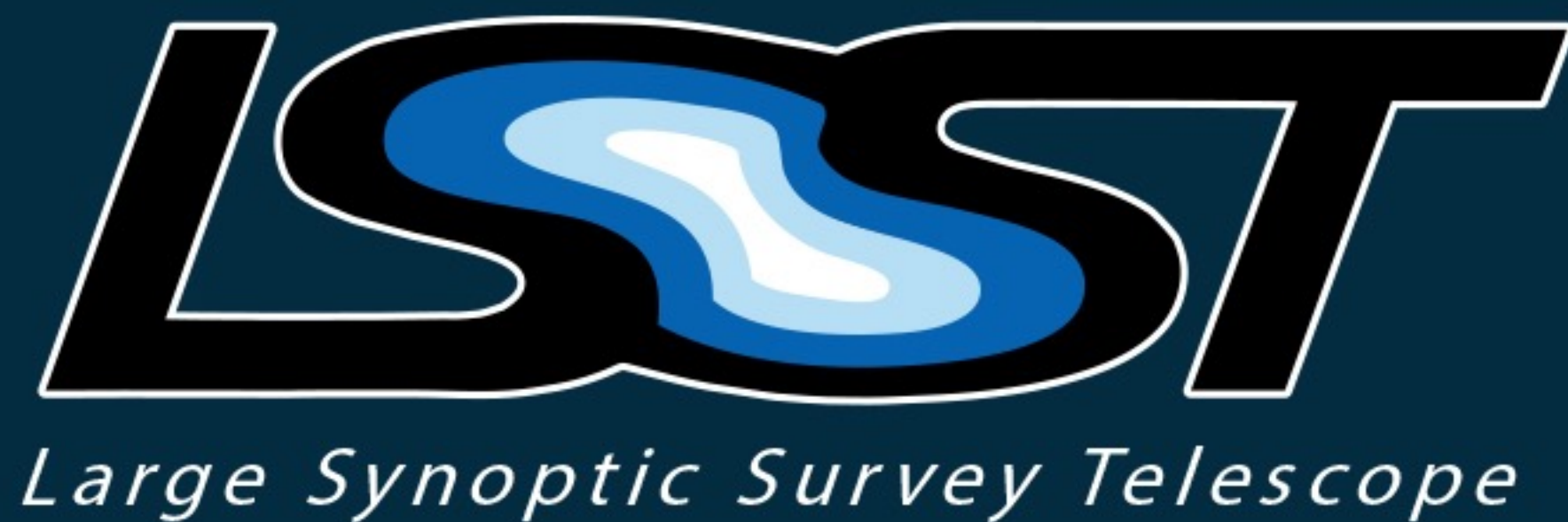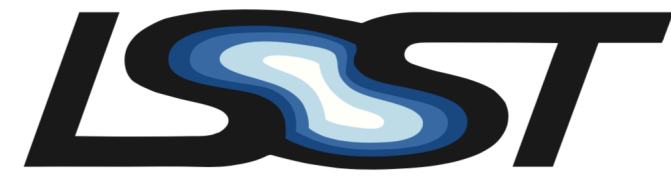# DIAObjects & Timeseries Features: Options and Open Questions

Eric Bellm, Alert Production Science Lead

DM-SST
27 January 2020

LSST will pre-compute timeseries features for lightcurves.

Difference Image (DIAObject) lightcurve features

- computed on DIASources during Prompt Processing and DIAForcedSources (TBC) during Data Release Processing

- included in alerts, the Prompt Products Database, and Data Releases

Direct Image (Object) lightcurve features

- computed on ForcedSources during Data Release Processing

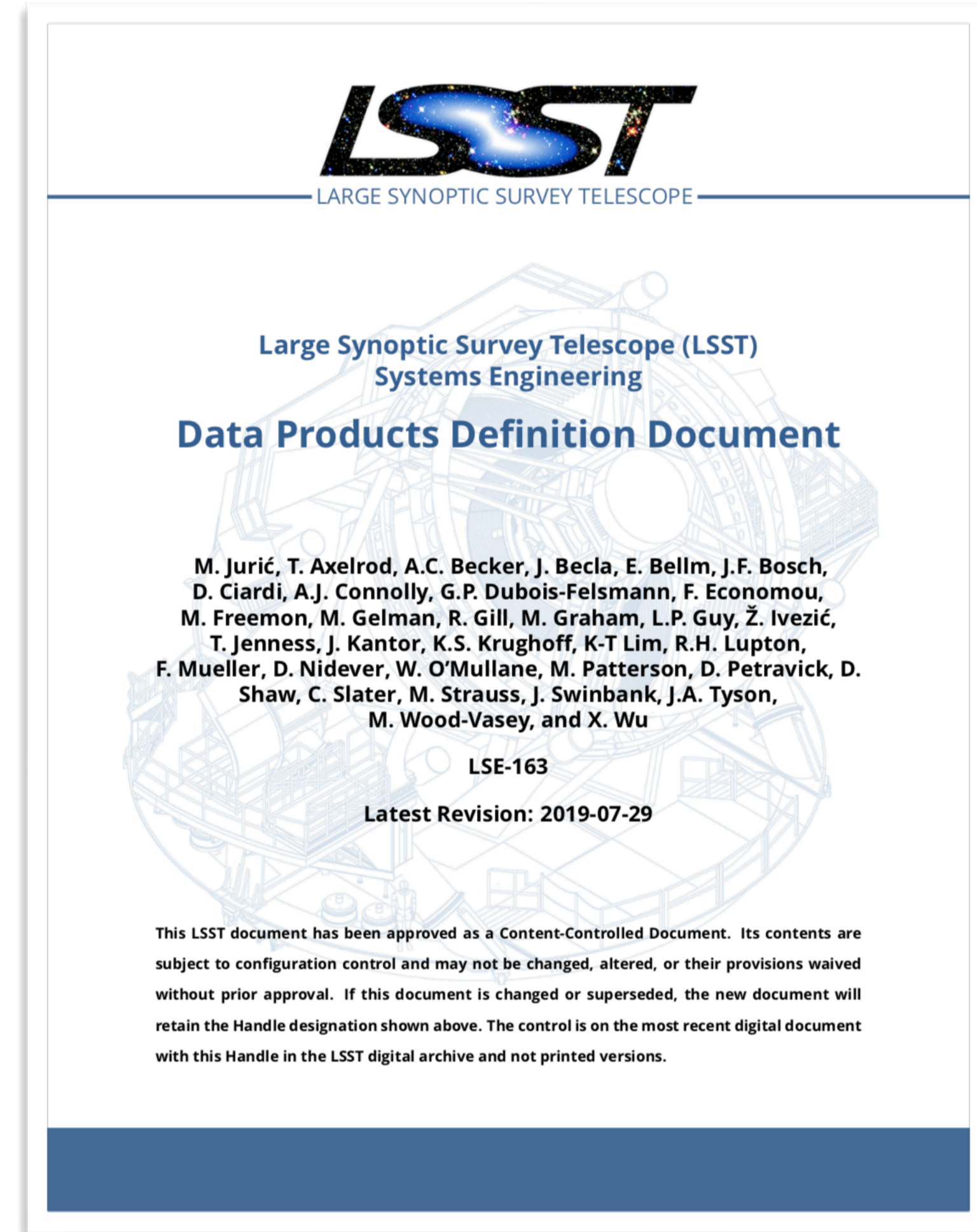- included in Data Release catalogs

The Data Products Definition Document allocates space:

lcPeriodic   float[6 × 32]   Periodic features extracted from DIA-Source light-curves using generalized Lomb-Scargle periodogram [Table 4, 17][48].
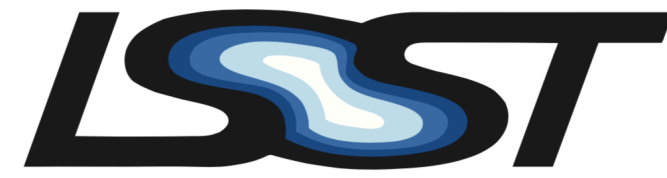
lcNonPeriodic   float[6 × 20]   Non-periodic features extracted from DIASource light-curves [Table 5, 17].

# of LSST filters   # of features

Large Synoptic Survey Telescope (LSST)
Systems Engineering

Data Products Definition Document

M. Jurić, T. Axelrod, A.C. Becker, J. Becla, E. Bellm, J.F. Bosch, D. Ciardi, A.J. Connolly, G.P. Dubois-Felsmann, F. Economou, M. Freemon, M. Gelman, R. Gill, M. Graham, L.P. Guy, Ž. Ivezić, T. Jenness, J. Kantor, K.S. Krughoff, K-T Lim, R.H. Lupton, F. Mueller, D. Nidever, W. O'Mullane, M. Patterson, D. Petravick, D. Shaw, C. Slater, M. Strauss, J. Swinbank, J.A. Tyson, M. Wood-Vasey, and X. Wu

LSE-163

Latest Revision: 2019-07-29

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see http://ls.st/dpdd

The baselined timeseries features are taken from Richards et al. 2011.

Characterization of periodic variability

Characterize lightcurve as the sum of a linear term plus sinusoids at three fundamental frequencies plus four harmonics:
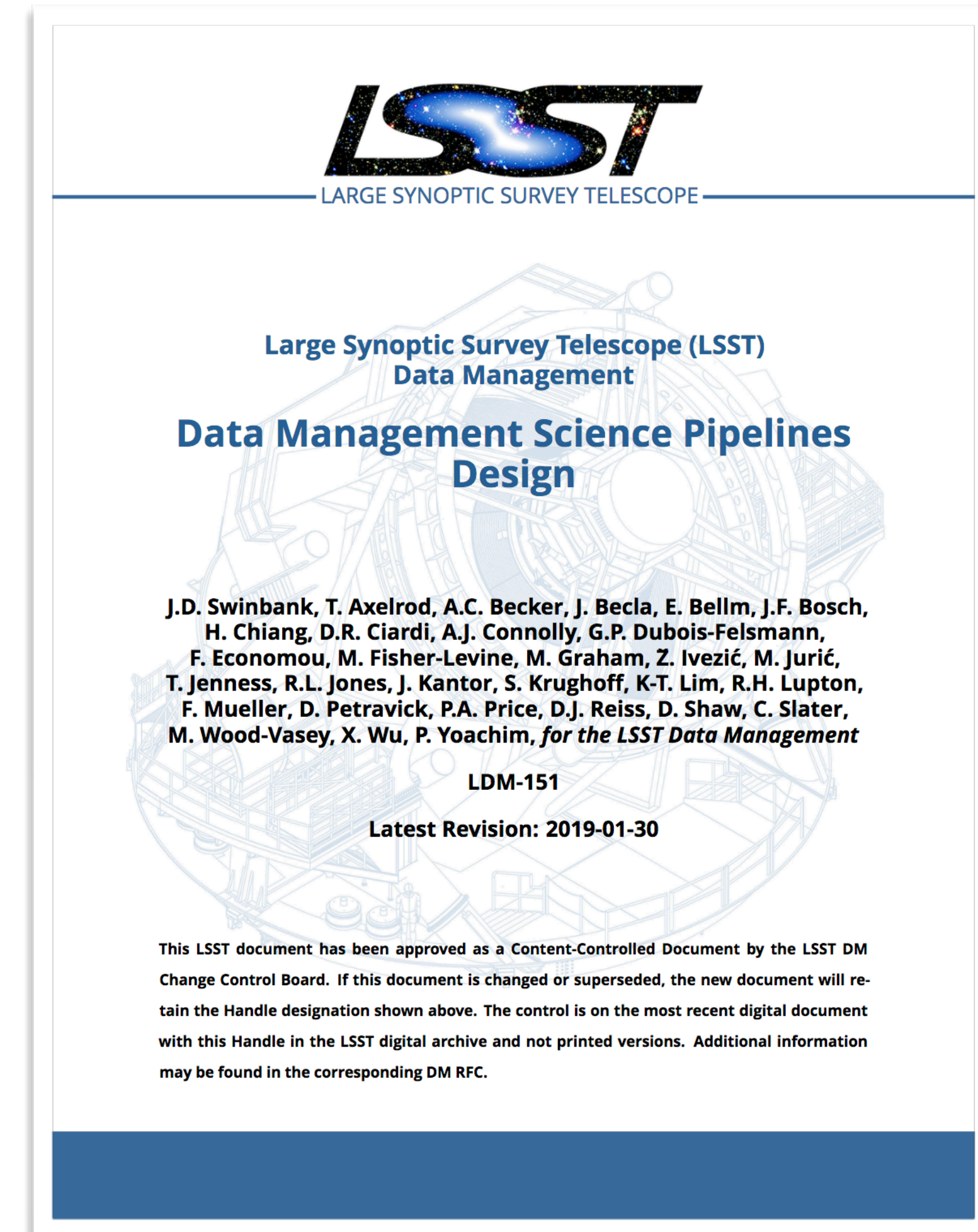
$$y(t) = ct + \sum_{i=1}^{3} \sum_{j=1}^{4} y_i(t|jf_i) \qquad (7)$$

$$y_i(t|jf_i) = a_{i,j}\sin(2\pi jf_it) + b_{i,j}\cos(2\pi jf_it) + b_{i,j,0} \qquad (8)$$

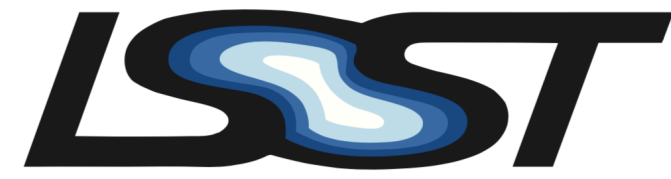- Report frequencies, amplitudes, phases, significances

Characterization of aperiodic variability

- max-min, maximum dm/dt, MAD, slope trend

- moments, percentile amplitude ratios, Stetson indices

- fraction of measurements near/away from median/mean

Large Synoptic Survey Telescope (LSST)
Data Management

Data Management Science Pipelines Design

J.D. Swinbank, T. Axelrod, A.C. Becker, J. Becla, E. Bellm, J.F. Bosch, H. Chiang, D.R. Ciardi, A.J. Connolly, G.P. Dubois-Felsmann, F. Economou, M. Fisher-Levine, M. Graham, Z. Ivezić, M. Jurić, T. Jenness, R.L. Jones, J. Kantor, S. Krughoff, K-T. Lim, R.H. Lupton, F. Mueller, D. Petravick, P.A. Price, D.J. Reiss, D. Shaw, C. Slater, M. Wood-Vasey, X. Wu, P. Yoachim, *for the LSST Data Management*

LDM-151

Latest Revision: 2019-01-30

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see http://ls.st/LDM-151 6.21

# There is a clear need to update the baselined features.

Choice of features was always intended as provisional; nearly a decade more progress since!

- many new features reported in the literature
- state of the art classifications may not use features at all

Substantial differences between Richards et al. 2011 and LSST:

	Richards et al. 2011	LSST
bands	single	six bands
features used for	ML classifier	alert filtering, user queries, ML classifiers
objects studied	variable stars	variable stars, transients, AGN, solar system objects….
number of features	~unconstrained	limited by storage space
computation time	~unconstrained	must fit in 60 second latency

DMTN-118 is an attempt to update the baseline features.
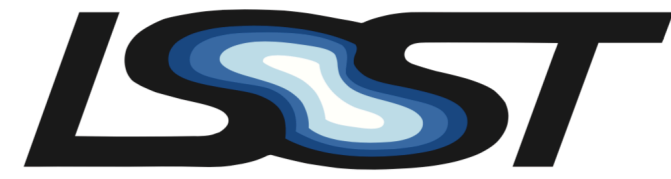
Review of Current Baseline (Richards et al. 2011)
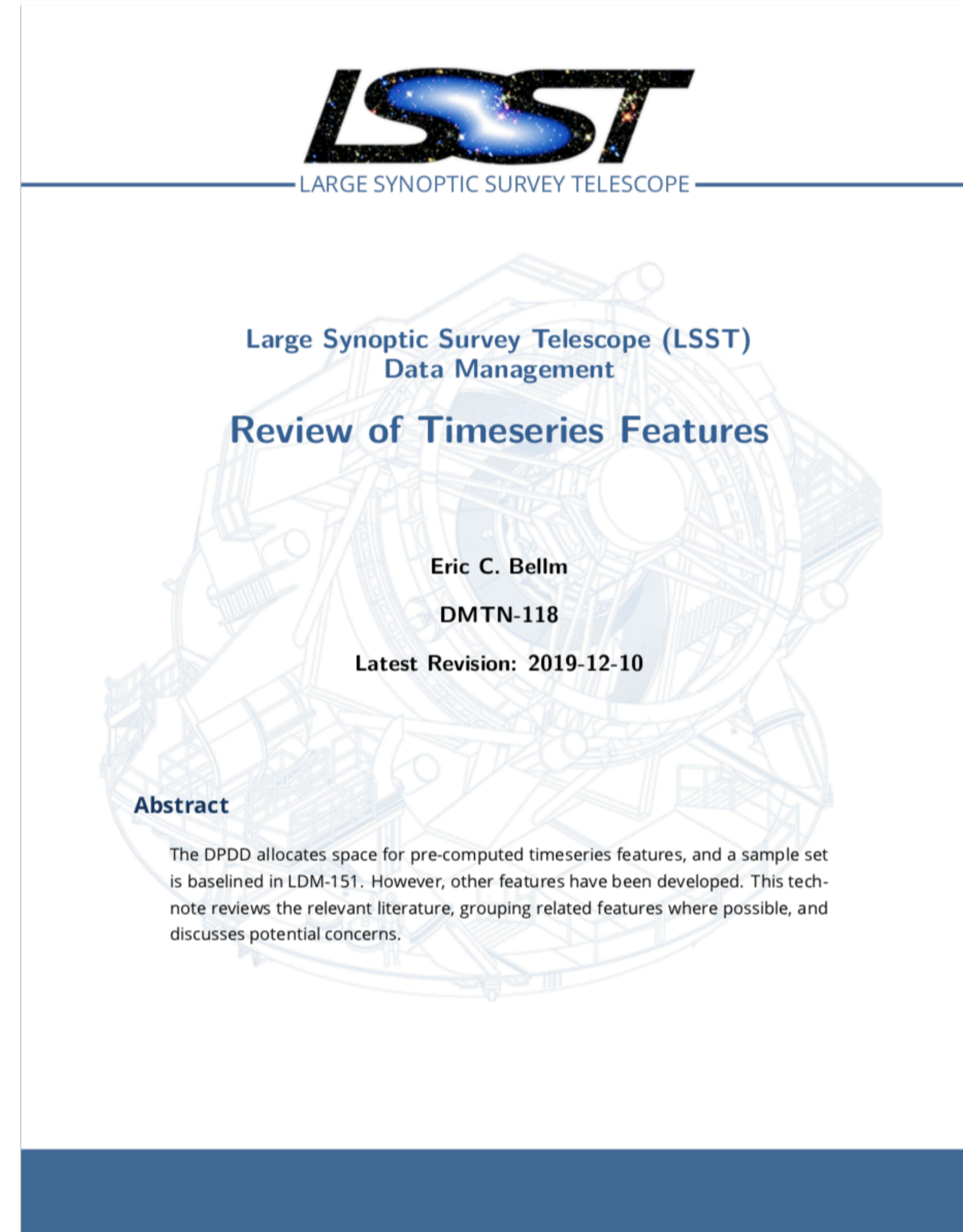
Motivations for updating features

Other Timeseries Features in the Literature

- Periodic

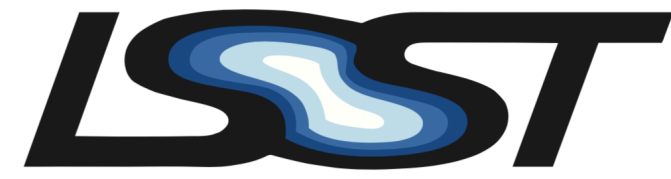- Aperiodic

- Transient

Open Questions

Recommendations

Proposed Feature Set

https://dmtn-118.lsst.io/v/DM-19593/index.html

SST input on the "Open Questions" would be valuable.

Should AP's DIAObject features be the same as the DRP DIAObject and Object features?

Should LSST perform science-specific model fits? (e.g., fits to SN lightcurve models)

Should we compute features on difference or total flux (or both)?

Should we use forced photometry measurements (either on difference images or PVIs) to compute timeseries features in AP?

*Would special programs benefit from unique timeseries features, and could this be accommodated technically?*

Should we consider storing features in non-floating-point formats to save space?

Should SSObjects have identical features to DIAObjects?

How can we choose which features to implement?

Will LSST compute the same features over the ten year survey?

Further discussion and iteration is needed.
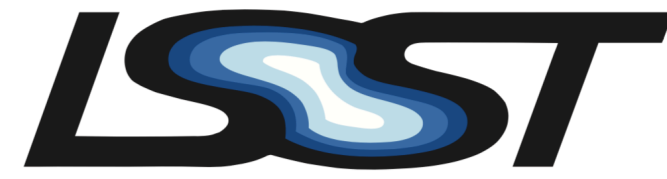
~now: interested SST members read current draft of DMTN-118 & give feedback

spring: Eric & interested parties draft concrete feature list

summer: DMTN-118 circulated to Science Collaborations for discussion & feedback

fall: implementation and performance testing of selected features

winter+: validation, further refinement, performance tuning