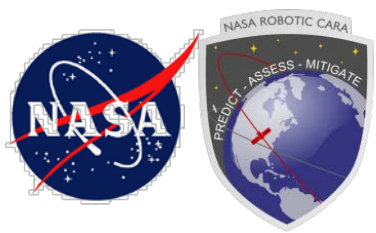


# Conjunction Assessment Risk Analysis



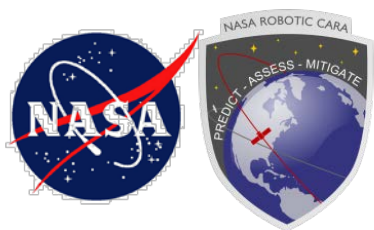
## CARA Commercial CA Data Experiment

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December 2019



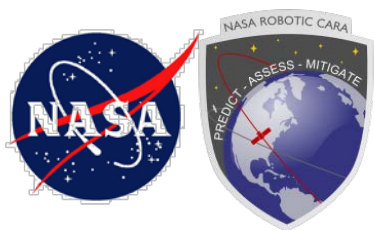
# Agenda

- **Commercial SSA data history**
- **Commercial SSA data major vendors**
- **Data nomenclature and possible benefits to CA**
- **CARA commercial CA data experiment description**
- **Experiment expected timeline**



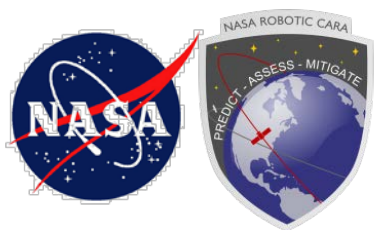
# Commercial SSA Data: Brief History

- **SSA sensors used to be very expensive to build and operate**
  - Previously the purview of governments, usually the military
- **Commercialization of telescope technology brought changes**
  - Surprisingly capable telescopes can now be assembled from mail-order parts, often for tens of thousands of dollars
- **Result was proliferation of small telescopes**
  - Led by ExoAnalytics (originally a missile defense contractor with experience with optical instrument construction and data processing)
  - Now several vendors involved
- **Commercial SSA radars also deployed and expanding**
- **Vendors selling not just tracking data but SSA products**
  - Vectors, covariances, and ephemerides from their “ghost” catalogues
  - Satellite signature data (radar cross-section, photometry)
  - Products traditionally called Space Object Identification (e.g., payload stability analyses)



# Commercial SSA: Current Major Vendors

- **ExoAnalytics**
  - 250+ optical telescopes with worldwide dispersion
- **Numerica**
  - Handful of telescopes, with advanced SSA products and services
- **L3 Harris (formerly ADS)**
  - Handful of telescopes, also with advanced SSA products and services
- **LeoLabs**
  - Two UHF and three planned S-band sites, with worldwide basing
  - Catalogue and CA products and services
- **Rincon Research**
  - Passive RF tracking of active payloads
- **Space Data Association (SDA)**
  - Middle-man for commercial tracking but do not of themselves own or operate SSA sensors
  - Incorporate data from some of these commercial vendors



# Commercial SSA: Data Type Nomenclature

- **Augmented catalogue**

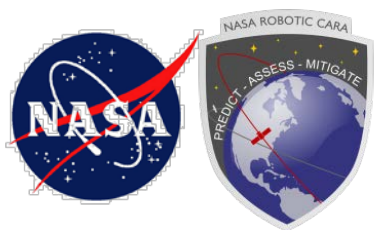
- Satellites well and consistently maintained by a commercial provider (or with commercially-provided data) that are not contained in the DoD catalogue
- Due to lack of SSN sensitivity or routine trackability

- **Enhancing data**

- Commercial data provided on an object that is already routinely maintained in the DoD catalogue
- Can be either
  - Tracking data, which conceptually can be combined easily with DoD tracking data to produce ensemble solutions
  - Orbit solutions, which can be combined with DoD solutions/data only with difficulty

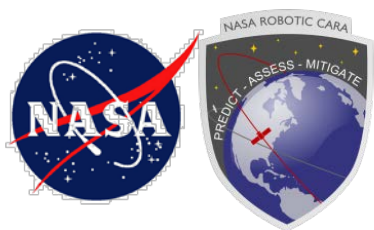
- ***Two policy notes***

- *DoD is the maintainer of the official catalogue per National Space Policy*
  - *Interpretation is that USG agencies must use DoD catalogue as a minimum*
- *NASA may purchase any particular dataset only if DoD declines to do so*



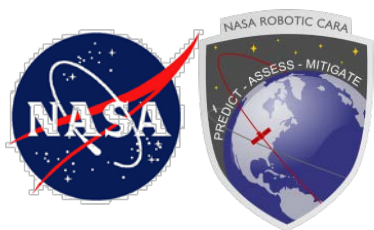
# Commercial SSA Data: Areas of Potential Benefit

- **Augment catalogue with additional objects**
  - Can do this, but practice raises substantial philosophical issues (next slide)
- **Improve OD quality at epoch**
  - For sparsely-tracked DoD objects, this will be helpful
  - But overall, improving OD fit quality will not appreciatively affect CA
    - Most state error at TCA is not fit error but prediction error
    - Extra-OD prediction errors rapidly swamp fit improvements (due to poor atmospheric density forecast error and primitive SRP models)
- **Reduce prediction time (through providing more tracks closer to TCA than SSN presently furnishes)**
  - If commercial data can actually do this, can be a notable improvement
    - But can be helpful only if satellite mitigation action timelines also improved
  - Will need substantial persistence to achieve real benefits here
- **Benefits dependent on orbit regime**
  - DoD catalogue quite strong in LEO; less so in HEO/GEO



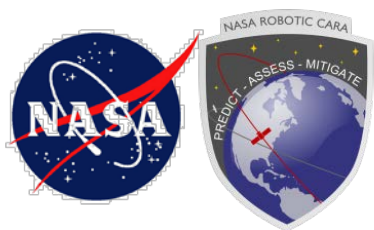
# Commercial SSA Data: Augmented Catalogue Philosophical Issues

- **Debris production requirements addressed by ODPO**
  - Shielding and 25-year rule are only firm debris mitigation requirements
  - On-orbit CA simply part of “avoiding the avoidable”
    - Mitigation thresholds will come out in CA Standard, but these not presently part of overall debris production risk decomposition
- **Thus, what is the “required” catalogue against which to screen?**
  - DoD is government product; set as minimum standard by NSP
  - Collision risk from objects not in DoD catalogue presently part of background risk assumed simply by launching a satellite
  - Any commercial catalogue bound to improve with more/better sensors
    - Will always be an emerging catalogue upgrade one could make
  - Unlikely ever to get to maintainable, actionable 1cm catalogue, which is level at which satellites shielded
- **For these reasons, difficult to justify increasing screening catalogue beyond DoD catalogue**



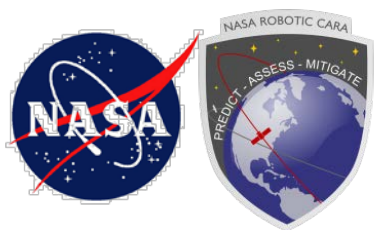
# Commercial SSA Data: CA Utility Analysis

- **CARA asked by HQ OCE to provide annual evaluation of cost/benefit of commercial SSA data for Agency CA**
  - Cost/benefit trade-off difficult to resolve, especially since NASA access to DoD data is essentially free
  - However, can attempt both to quantify and qualify the benefit
- **Not presently planning to evaluate CA against augmented catalogues**
  - Technically difficult and (presently) lacking in philosophical mandate
  - However, can evaluate improvements derived from using enhancing data
- **CA metrics of interest: reclassification of events (red/yellow)**
  - Accuracy and precision improvements, taken alone, not conclusive for CA
    - Presumed that more abundant, pooled commercial and DoD tracking data will produce more accurate state estimates and precise covariances
  - # / % of events recategorized (red to yellow and yellow to red)
  - Time point (time to TCA) at which recategorization takes place



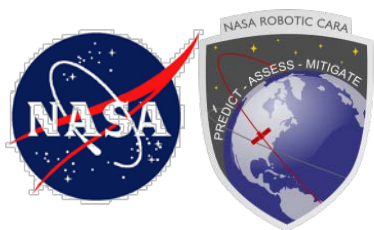
# CARA Commercial CA Experiment: Data Sources

- **Air Force Research Laboratory (AFRL) proof-of-concept initiative**
  - Small number of telescopes, providing tracking on all orbit types
- **LeoLabs data to be purchased by NOAA**
  - Principally in support of improved ephemeris generation for primaries
  - However, tasking for NOAA conjunction secondaries expected to be included
- **Other tracking data purchased by DoD**
  - Exoanalytics, Numerica, L3 Harris, LeoLabs
- **Data relevance for CARA missions not entirely clear**
  - Amount of data could be large
  - Lack of mandatory response to tasking and bias to HEO/GEO may reduce data pool relevance



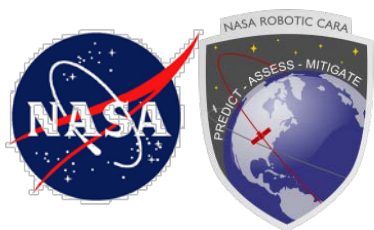
# CARA Commercial CA Experiment: Data Collection and Forwarding

- **CARA worklist sent daily to participating vendors**
  - Only some actually required to respond, but available as option for all
  - Red and yellow events, sorted by color and OD quality
- **Tracking data taken by vendors and uploaded to UDL**
  - “Unified Data Library” is AFRL experimental SSA data repository
- **Data pre-processed by CODA functionality**
  - “Consolidated SSA Operational Data Archive”
    - Identifies data (from UDL and elsewhere) to upload to 18 SPCS operational system
    - Performs any needed transformations (coordinate system, corrections)
    - Assesses data quality and appends tracking weight and bias data
    - Assigns SSC # (perhaps most important function)
- **Data uploaded to 18 SPCS system via NDPP**
  - “Non-traditional Data Pre-Processor”
  - Provides low-to-high data upgrade and places data in desired destination



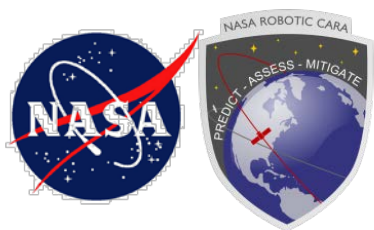
# CARA Commercial CA Experiment: Use of Commercial Data in CA Processes

- **In working worklist items, OSAs will determine if commercial data exist for particular conjunctions**
  - For red and high yellow events, will make use of such data
  - For other worklist events, may employ data if daily workflow permits
- **Updates will be performed using only SSN data**
- **Additionally, updates will be performed using pooled data**
  - Combined SSN and commercial tracking data
  - Written to “sandbox” area of system so as not to update official catalogue
  - CDM generated from 1 v 1 screening
- **If commercial CA data sustain CARA validation (likely), then pooled-data CDMs can be used to drive operational decisions**
  - Need to work out mechanism for this for devolved missions
- **CARA manual participation in process may be sufficient to enable commercial-data-driven updates to official catalogue**



# CARA Commercial CA Experiment: Commercial Data Evaluation

- **General evaluations of tracking data accuracy**
  - Necessary for data source validation
- **Comparison of event severity with and without commercial data**
  - Upgraded/downgraded events
  - Point at which event is upgraded or downgraded
- **Potential evaluation of commercial CA products**
  - Will pursue this only if convenient
- **Will not be evaluating augmented catalogues**



# CARA Commercial CA Experiment: Timeline

- **Tests of key parts of system in November and December**
- **Plan is to begin “as-described” experiment in early January**
  - CODA/NDPP should be ready in test configuration in December
  - Data available in January time-frame; potentially subject to delays
    - Funding-related issues in standing up new AFRL experimental sensors
- **Will run experiment as long as data available**
  - Current plan is to run at least through end of FY20
  - May need quite extended period to gather enough data to allow durable conclusions to be drawn
  - Experiment could be stymied by success—if USAF decides to pipe commercial data directly into catalogue, may lose insight into added benefit