Conjunction Assessment Risk Analysis

CARA
Commercial CA Data Experiment

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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
• **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
• 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
• 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