The Study Group problem: EMITTER-PLATFORM ASSOCIATION

Neil Cade, SELEX Galileo Ltd.

Given Intercepted Radio Frequency (RF) emissions, provide a prediction of the number of underlying source platforms and the association between the emissions and platforms.

Intercepted RF electromagnetic signals provide a good long-ranged source of information on the motions and activities of people, vehicles, installations and organisations. Such sources range from mobile phones at the low frequency end, though surveillance radar (air traffic control) to millimetre guidance radar (car collision avoidance), all of which produce intermittent pulse signals of varying frequency, inter-pulse timing and pulse shape. This is a very broad spectrum and typically, broadband RF receivers will potentially be able to detect several hundreds of sources at any time instant. For those emissions that are detected, traditional tracking methods are used to associate the separate low level interceptions and average their characteristics to obtain tracks of the source location and characteristic patterns of the emissions.

Even this traditional tracking problem is complicated:

- The emissions are sporadic, consisting of short bursts of emission interspersed with long quiescent intervals.
- The individual sources have multiple modes of operation (e.g. mobile phones may be transmitting voice or data or station-polling signals)
- Location information is only in terms of noisy measurement of azimuth and elevation angle.
- Platforms can have multiple sources of emission. E.g. a ship may have several different types of Radar, or a bus may have several people using their mobile phones at the same time.
- The interceptor sensors are also likely to be on moving platforms and will not necessarily have a consistent visibility of the sources (occlusion, multi-path, …)
- The emission is dense enough that the emission patterns from different sources are bound to overlap with at least one other source.

Therefore it is inevitable that the traditional tracking will have introduced some additional track errors from mis-associations that in turn result in incorrect classifications and location distortions

The proposed project takes this emitter track data from the intercepted RF emissions as given. The multi-target track data is a sequence of time-stamped state vectors comprising continuous (angle) components, estimates of the maximum possible ranges of the data sources, an identity that associates the individual emission belonging to the separate tracks and the associated uncertainties of these characteristics.

The task is to provide a best many to many match, supported by some measure of the quality of match, between the emissions and potential platforms at all times, on the basis of previously seen data. Issues needing to be addressed include:

- The emission sequences associated with a single identity may be wrong. For example the same type of emission might come from multiple platforms of the same type and may therefore have been incorrectly associated with a single track.
- Platforms of the same type can have very different emissions
- Platforms can have emissions overlapping in time
- Ambiguities may become resolved as the targets approach the sensor system or as different platforms move relative to each other.
- The accuracy of the track data can vary greatly between different tracks and over the evolution history of a single track.

- The need to avoid discontinuous jumps in the mappings as time evolves. Ultimately, the primary interest is in the underlying platforms and it is particularly disconcerting if the solution 'chatters' between almost equally likely alternatives

The problem might be tackled in many ways but it might be useful to consider in varying degrees of complexity:

1. Consider the complete tracks pair-wise and determine for each pair whether it is possible for the pairs of emissions to have originated from the same platforms.
2. For those same pairs of tracks consider the time-stamped data in order and find the earliest time at which it is possible to determine whether the tracks arise from the same platform or not
3. Provide estimates of the motions of the platforms knowing the sensor trajectory that is common to all the data. This might be provided in terms of the best estimates, as a function of time, for the azimuth, elevation and range of all platform groups including estimates of the expected errors given the positional uncertainty of the components and the likelihood that association is correct.

Example data

The data is in tabular form giving the tracks with track angles and their errors as a function of time, along with labels and numerical data that describe the tracks. The latter data is used to associate the tracks with a set of possible platforms. Since these tentative associations have already been made, this additional data is not strictly necessary. A typical very short time-slice of data is shown below in Table 1. Over a longer time there is significant angle variation and a greater variety of tracks. This single table does not represent all the useful information. In particular, some but not all platforms can have multiples of the same RF sources.

Time	Track Number	Az / °	El / °	Az Error (sd) / °	El Error (sd) / °	Maximum Range / km	Range error dB
0.00810185	25	131	8	17.4	16.5	130	-3
0.00809788	25	173	-2	11.3	8.9	100	-3
0.00812338	25	172	40	9.6	6.8	110	-3
0.00817988	38	-93	-29	8.1	4.9	25	-3
0.00820385	26	-28	40	15.9	14.6	250	-3
0.00821116	25	151	16	12	9.8	140	-3
0.00826041	30	-12	45	9.2	7.3	57	-3
0.00827192	25	179	46	11.3	9.9	145	-3
0.00827226	52	50	79	9.7	7.9	55	-3
0.00828074	40	140	41	12.2	11.0	200	-3
0.00829260	26	-22	45	15.8	15.5	200	-3
0.00830400	25	-152	61	8.2	6.0	130	-3
0.00830550	26	-28	40	12.2	12.0	310	-3
0.00831748	26	-39	36	11.9	11.6	200	-3
0.00832039	30	-7	-3	16.1	16.9	150	-3
0.00833068	26	-28	39	12.5	12.4	220	-3
0.00838149	65	92	-3	6.9	4.4	27	-3
0.00838944	25	-122	-16	11.7	9.4	125	-3
0.00839598	65	89	0	7.1	3.6	35	-3
0.00840019	65	94	-5	7.3	4.9	50	-3
0.00840096	44	-136	3	10.9	8.4	140	-3
0.00841120	30	-6	-6	11.5	9.1	65	-3
0.00845928	65	95	-3	6.1	3.4	35	-3
0.00847579	63	99	-6	13	12.0	120	-3
0.00847612	63	98	-3	12.8	11.8	100	-3
0.00850428	65	90	-1	6.6	4.0	85	-3
0.00850010	77	10	-20	13.5	12.6	250	-3

Table 1 Short-time 'instantaneous' picture of RF sources their angular locations and possible ranges

In addition to this emission data the motion of the sensor platform is known and although the motions of the emitter platforms are not known, there will be natural limits on their dynamics and these will be specified in terms of maximum speed and acceleration rates that will be a function of the number of co-located emissions from them. Some platforms may be known to be ground static.