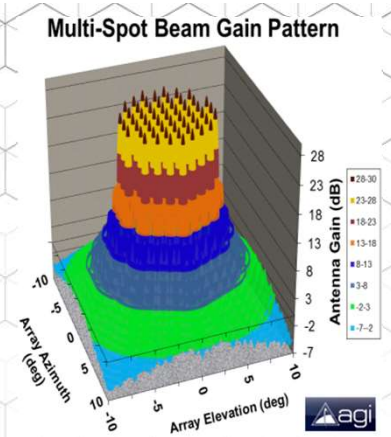
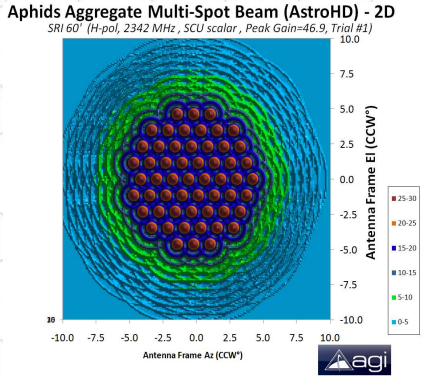
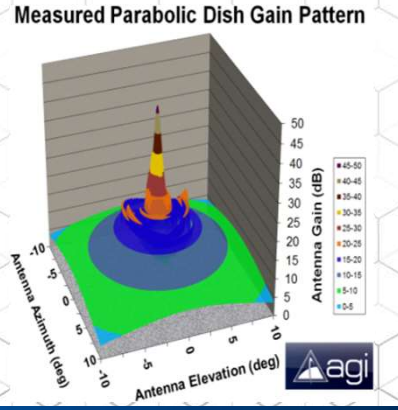
History of the SDA/COMSPOC initiative to add RFI Mitigation functionality to the SDC

Dan Oltrogge







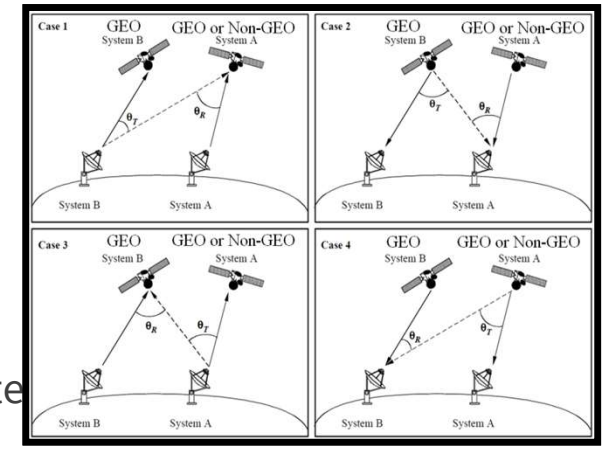
Excerpts from EMISSIONS briefing originally presented at the SDA Users Meeting on 16 March 2015

Motivations for SDA's Creation

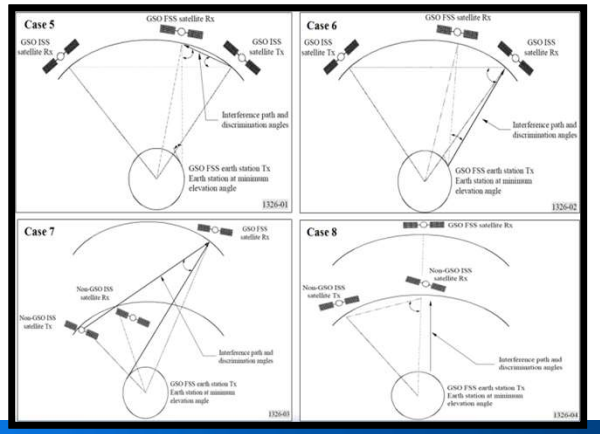
- Enhance "Safety of flight"
  - *Definition: The condition where satellites are positioned and operated in a manner that preserves their long-term operational viability, the long-term operational viability of any other satellites, and the preservation of the orbital regime(s) involved*
- EMI/RFI Geolocation and Resolution Support
  - More rapidly find and address interference sources
- Efficient, timely, accurate conjunction assessments
  - Consolidate and use best available data from operators, including planned maneuvers
  - Reduce false alarms, missed events
  - Minimize member time and resources devoted to CA
- SSA / Format Conversions / Information Repository
  - Minimize confusion, potential for conflicting decisions
- Encourage evolution of best practices for Members

Most Problematic RFI Paths:

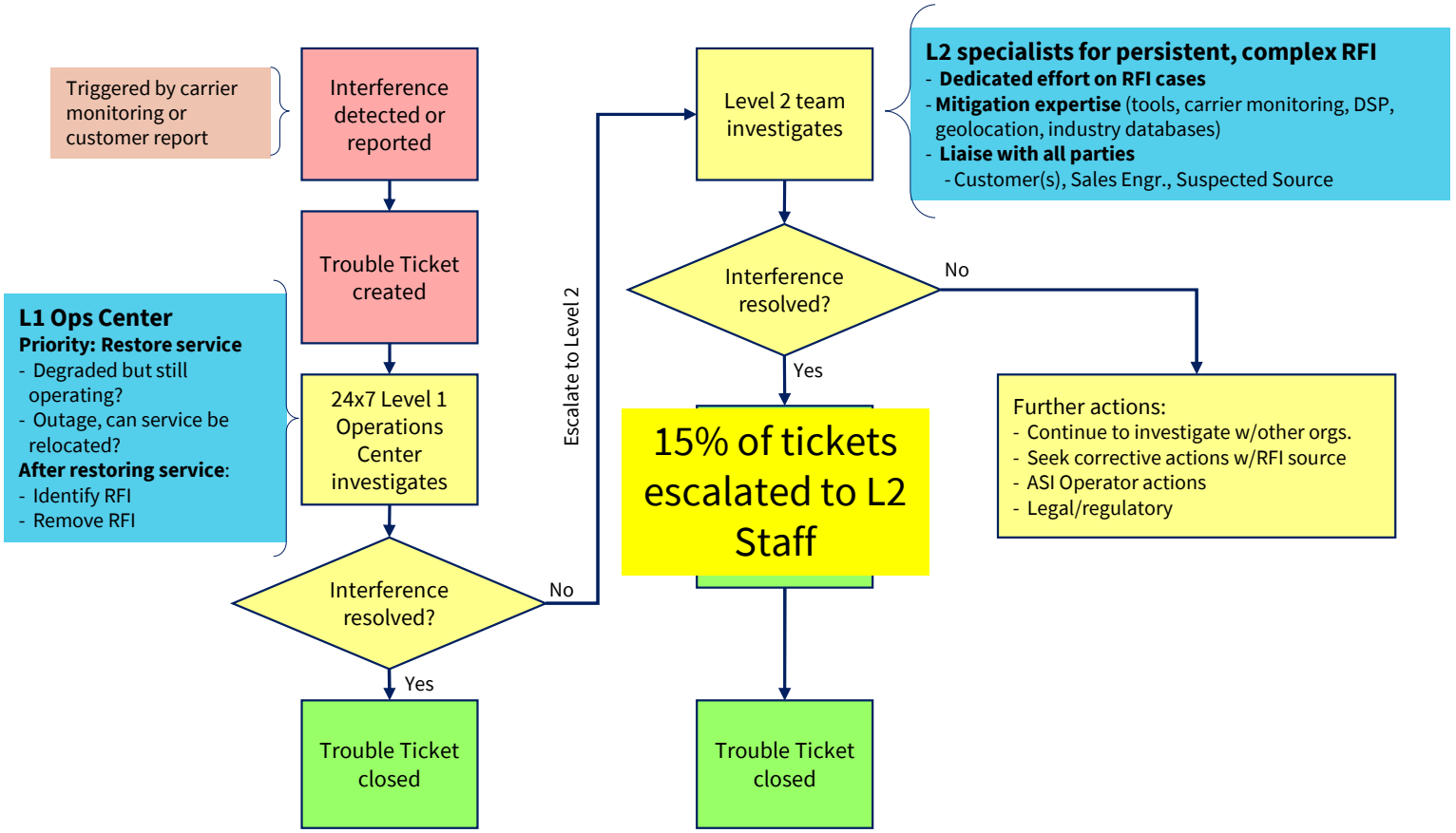
- 2 RFI types difficult to mitigate:
  - Satellites-to/from-Ground
  - Inter-Satellite vs GEO-to-Ground
- RFIs are either unintentional…
  - Bad Equipment, mistaken schedules or polarities, or “Fly-By” (LEOP or drifting) satellite
- or intentional (jamming/DoS)
  - Occurrence of intentional jamming varies by operator and satellite location, but is typically rare (<< 1%)



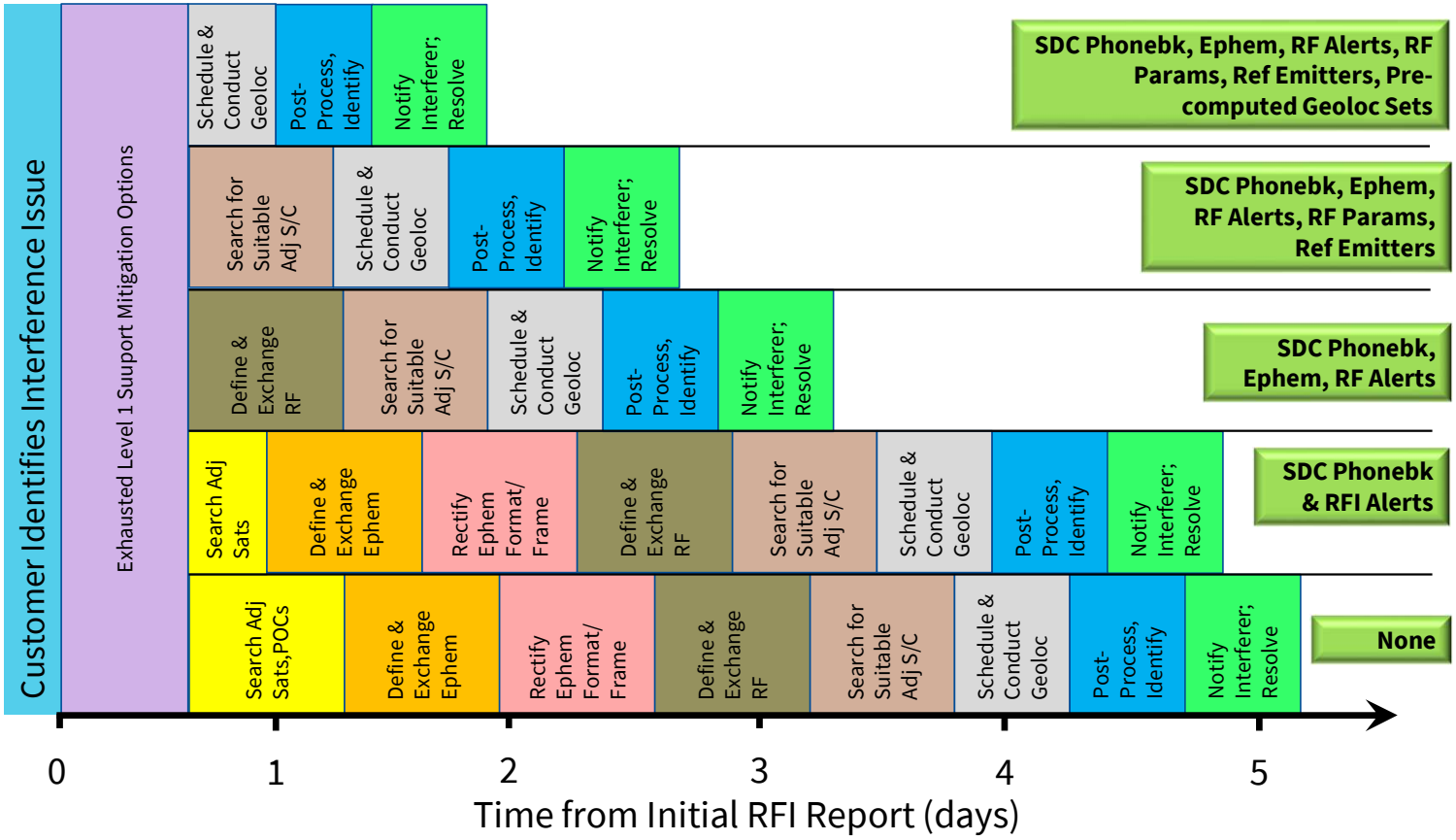
Source: ITU Recommendation ITU-R S.1526-1



Typical Operator Workflow for RFI Mitigation

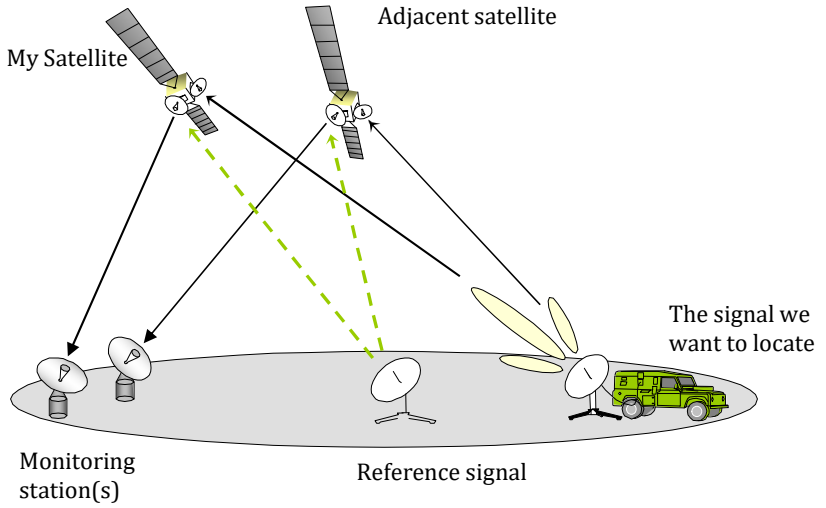


Summary: Improving RFI Mitigation Timelines



SDC/RFI – Introduction

- RFI background
  - RF interference is a major operational problem affecting customer services on geostationary satellites
  - ~85-90% of customer issues are due to RFI
  - RFI only affects a small amount of capacity but has a cost and service impact if not quickly resolved
  - Investigating RFI is time consuming – we are always seeking methods and processes to improve response
- Geolocation – key mitigation technique
  - One of the main techniques used to
  - identify interfering signals
  - Requires precise satellite ephemeris data
  - for 'affected' and adjacent satellites
  - Needs RF payload data for 'affected'
  - and adjacent satellites



SDC/RFI – Geolocation Support

- How can SDC help with geolocation?
  - Investigation often needs accurate RF data on other satellites
  - SDC already contains the precise ephemeris data
  - Need to extend data sharing to include RF payload data
  - SDA already has a means of securely holding and exchanging data with the users
  - It already has a legal framework to protect user's data

- SDC pre-computed geolocation solution sets
  - Analyze an RFI event submitted by an SDC user
  - Use knowledge of payload data for all satellites, to provide a ranked order of geolocation scenarios, to input into the user's geolocation system

Normalized RF Data & Approach

- Gathered relevant RF input data
  - SDA/AGI developed standardized Excel templates
  - Eutelsat, Intelsat, SES submitted payload RF data for handful of satellites
  - AGI developed analytical software EMISSION for geolocation pre-computation

Uplink Channel ID/Name	Uplink Beam Name	Uplink Unique ID (e.g. Composite of Beam and Channel IDs)	Uplink Coverage Region (e.g. North America)	Uplink Center Freq (MHz)	Uplink Polarization (H, V, LC, RC, LE, RE)	Rx G/T Specification via .GXT File		Rx G/T Specification via Antenna Pattern		
						Rx .GXT Filename	Offset to get Beam G/T (dB/K) G/T = Rx GXT + G/T_Offset	Rx Antenna Pattern Filename	Offset to get Beam G/T (dB/K) G/T = Rx Gain + G/T_Offset	Antenna mount biases: Az bias (deg) / El bias (deg)

ownlink Transponder ID/Nan	ownlink Beam Nam	Downlink Unique ID .g. Composite of Bea and Transponder IDs	equency Convert Local Oscillator ID	ownlink Coverage Regi (e.g. North Americ	ownlink Center Fre (MHz)	Downlink Transponder: Transmit Speed (Mbps)	Bandwidth (MHz) including guard band	ownlink Polarizatio H, V, LC, RC, LE, RE)	Tx EIRP Specification via .GXT File: IRP .GXT Filenam	set to get Saturated EIRP (dB EIRP = Tx Gain + EIRP_Offset	Tx EIRP Specification via Antenna Pattern: Gain Pattern Filenam	set to get Saturated EIRP (dB EIRP = Tx Gain + EIRP_Offset	Antenna mount biases: Az bias (deg)	El bias (deg)

Active Uplink Unique ID	Connected Downlink Unique ID	Transponder Mode (Choose either FGM, ALC, MUTE or OFF)	SFD (max Gain) dBW/m^2 @ G/T=0 dB/K

Site Name	Site Location (WGS84 Datum)			Transmit EIRP		Freq Range		Reference Emitter Uplink Polarization (Rcv'd at S/C) (H, V, LC, RC, LE, RE)
	Latitude (+deg E)	Longitude (+deg N)	Altitude (m)	Equiv. Parab Dish Dia. (m)	Power (dBW)	Center Freq MHz	Bandwidth MHz	

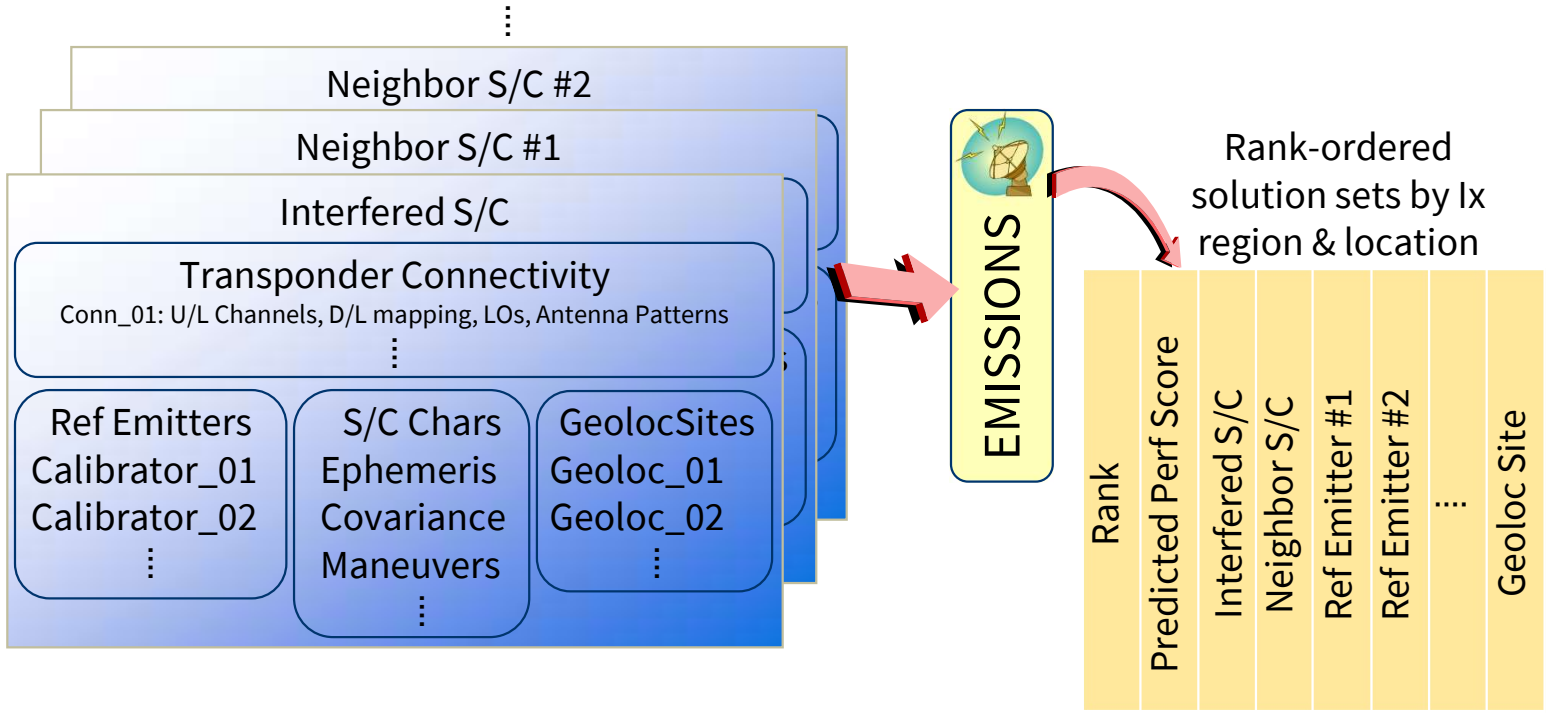
Site Location (WGS84 Datum)			Geolocation Antenna Params			Gelocation Site Frequency Ranges *(Enter "0" for Low and High if band not supported)*							
Latitude (+deg E)	Longitude (+deg N)	Altitude (m)	Equiv. Parab Dish Dia. (m)	System Noise (dBK)	C/N Req'd for Geoloc	C-band		X-band?		Ku-band?		Ka-band?	
						Low (MHz)	High (MHz)	Low (MHz)	High (MHz)	Low (MHz)	High (MHz)	Low (MHz)	High (MHz)

EMI Solution Set Identification of Optimal NeighborS (EMISSIONS™)

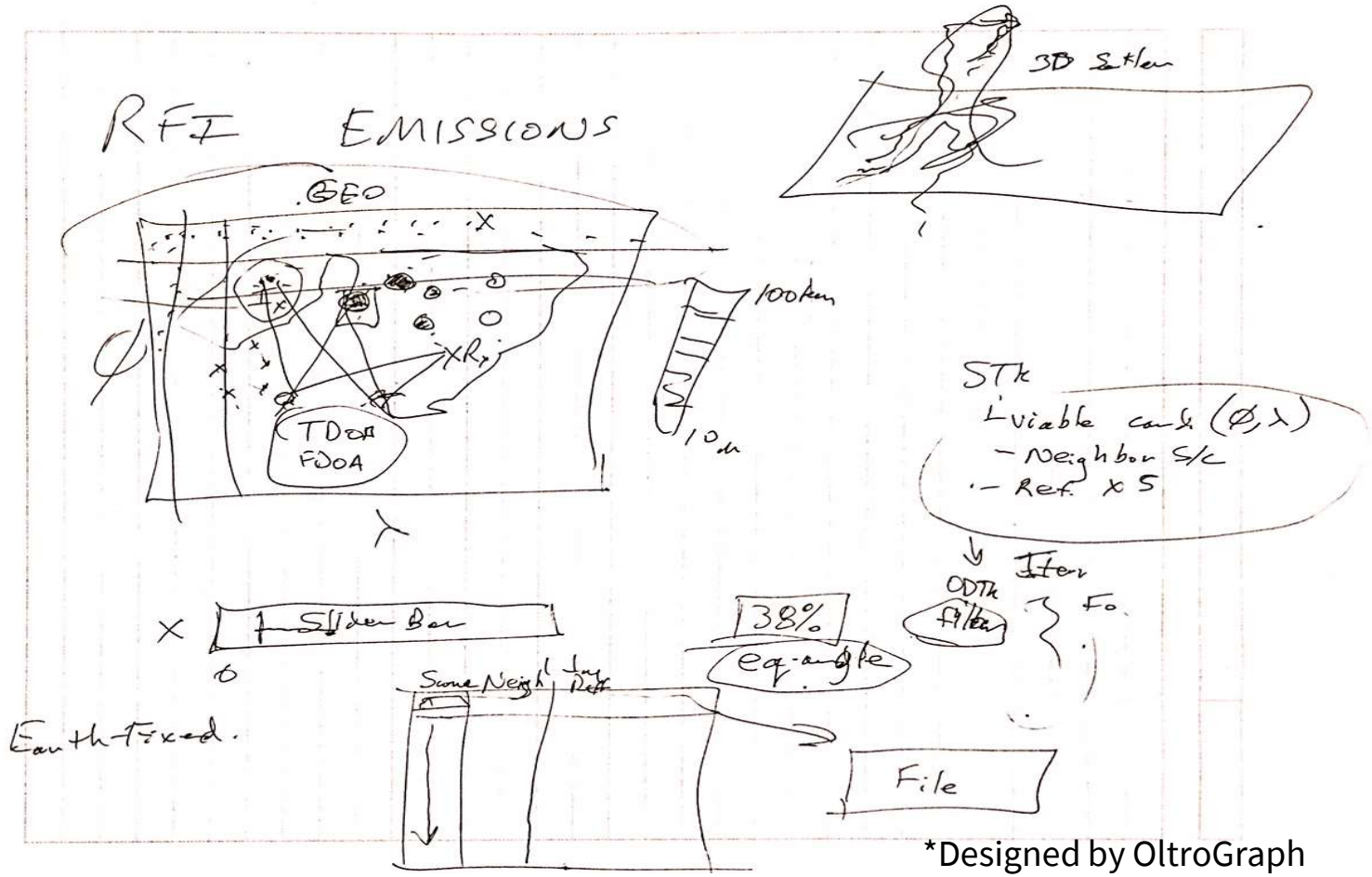
- EMI is chief concern for operators of satellite communications systems
- RFI mitigation initiatives
  - Inter-operator satellite operator Carrier ID Database
  - Equipment install training/cert programs
  - Geolocation of interfering signals
- Constructing a geolocation "Solution Set" w/normalized inputs **can take days to weeks**
- "EMISSIONS" Tool could construct an optimized solution set in minutes
  - Authoritative ephemerides + maneuvers + RF data + antenna patterns + aggregate reference emitters + geolocation sites + STK & ODTK under the hood

EMISSIONS Tool

- SDA is ideal trusted framework for behind-the-scenes RF analytics such as “EMISSIONS”
- Large quantity of proprietary RF data required:

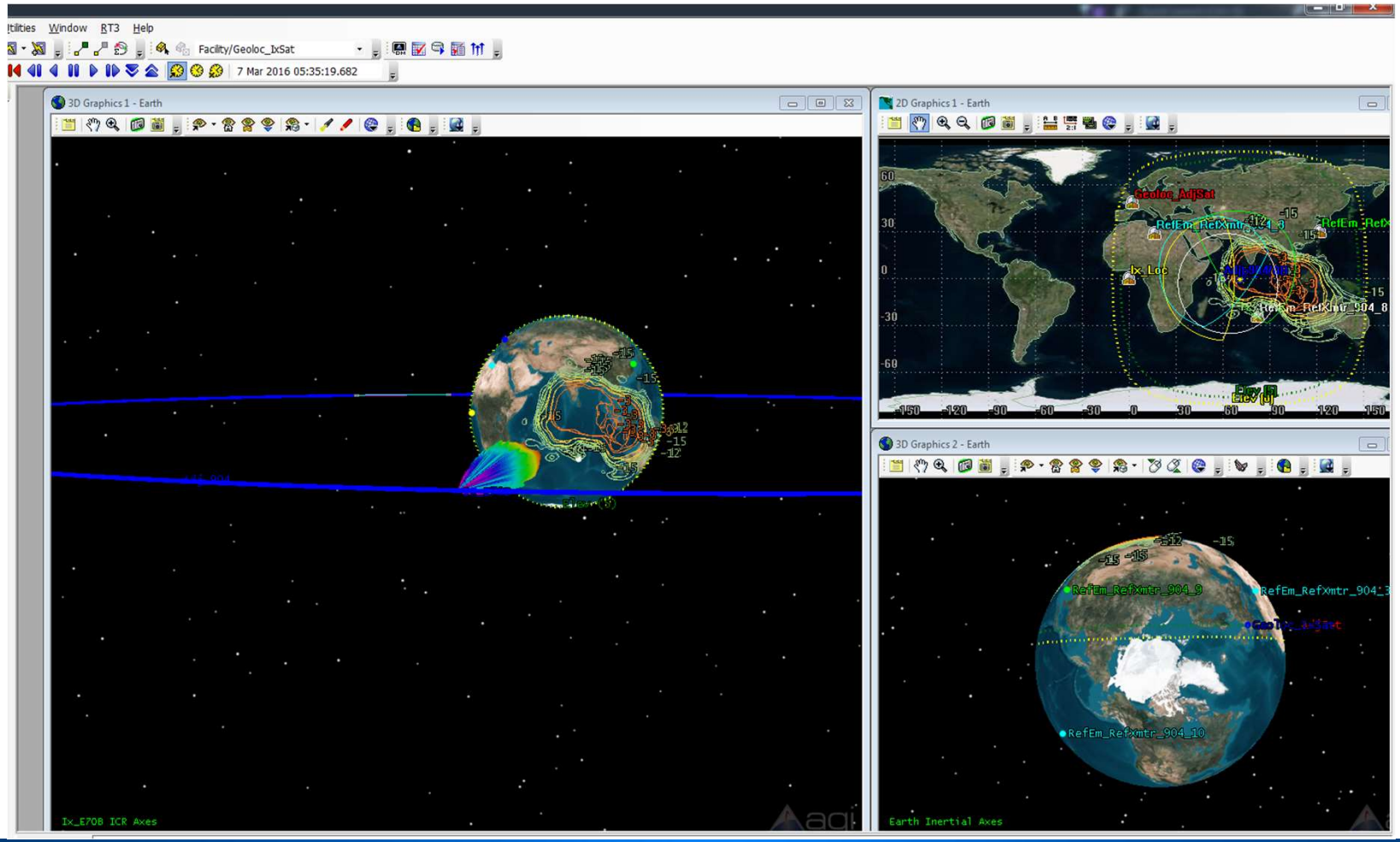


EMISSIONS Process Flow



*Designed by OltroGraph

Complete specificity of S/C RF is foundational to EMI mitigation



Current status

- EMISSIONS prototype completed…
  - EMISSIONs now exists in prototype form, producing “heavy” STK Comm objects for full RF analysis based on operator-provided RF parameters
  - EMISSIONS employs ODTK TDOA/FDOA filter to parametrically evaluate geolocation performance at interference sites
  - EMISSIONS does not have graphical display yet.
  - EMISSIONS capable of producing solution sets
- But then:
  - Discovered that the “Object Model” I’d employed in 2015 was simply too slow to do the sort of parametric evaluations and optimization that EMISSION was designed to do.
  - Since then, ANSYS Components library developed to perform this functionality much faster.
  - COMSPOC is developing relevant RFI assessment libraries.
- Could now explore suitability of implementing using Components
- COMSPOC willing to discuss today’s utility with SDA member RFI Level 2 SMEs