

ALMA – a real world example

Wolfgang Wild
European ALMA Project Manager



A new observatory

- Atacama Large Millimeter/submillimeter Array
 - 54 x 12m + 12 x 7m antennas on Chajnantor at 5050m
 - 7 – 0.35 mm (30-900 GHz) in 10⁺ atmospheric windows
 - World's most powerful radio interferometer
 - Cold Universe: formation of planets, stars and galaxies
- Global partnership
 - North America (37.5%), East Asia (25%) & ESO (37.5%)
 - In cooperation with Chile



■ Construction (1999 – 2013)

- All equipment procured/built by Partners
- Total investment 1200 MEUR
- ESO contribution corresponds to 475 MEUR
- ~45 fte at ESO for ALMA construction
- Most construction activities completed

■ Operations (since 2011)

- Started in parallel with construction (“Early Science”)
- Transition to full operations underway
- Coordinated by Santiago Central Office

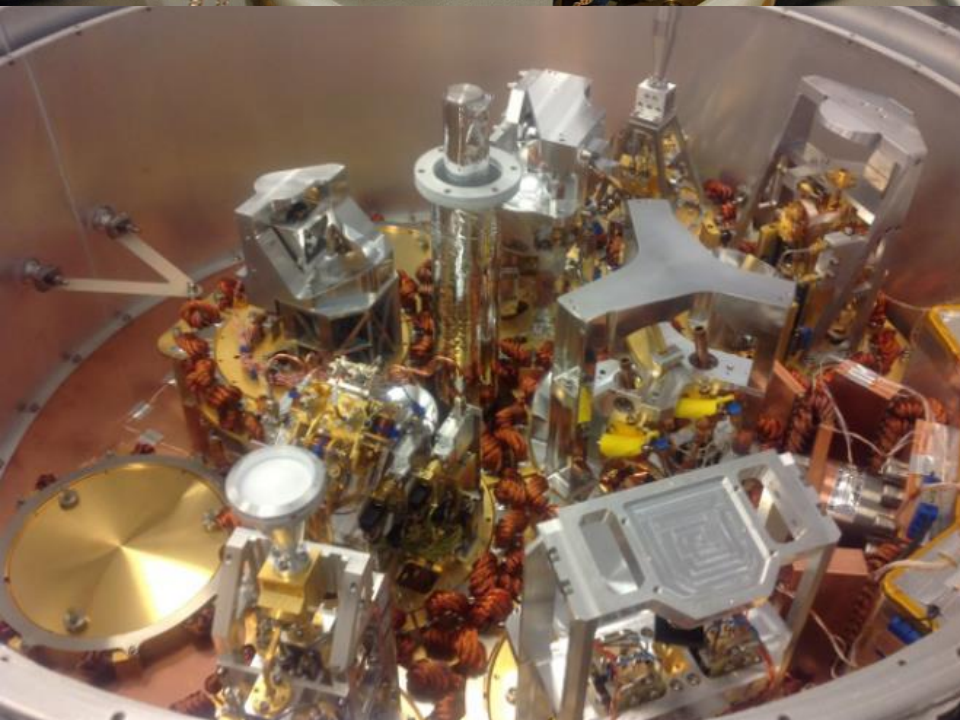
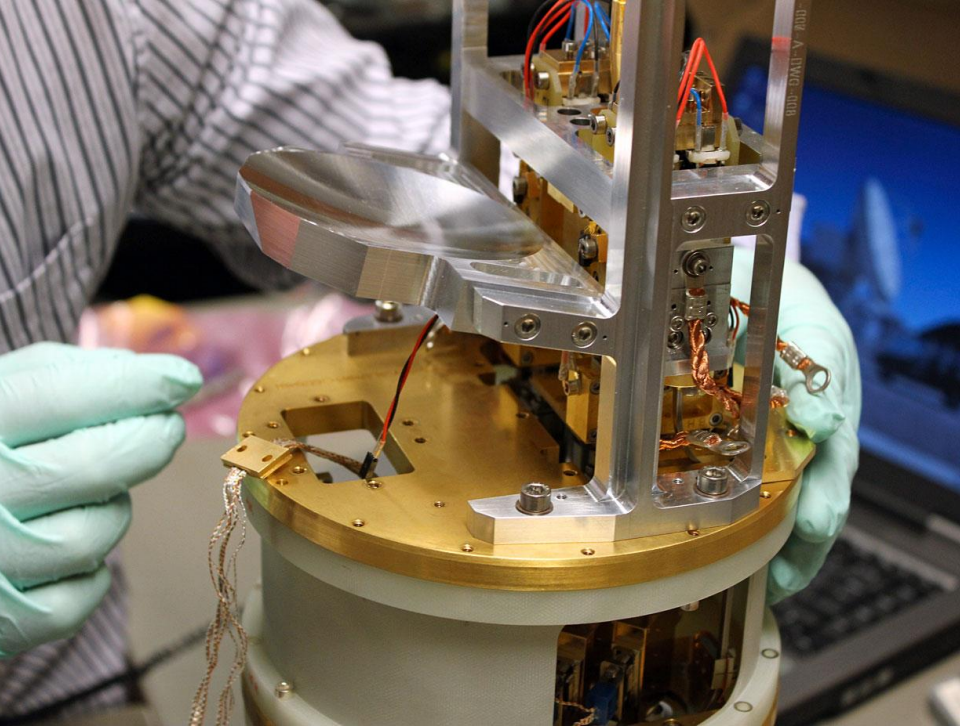
Array Operations Site (AOS), 5000m



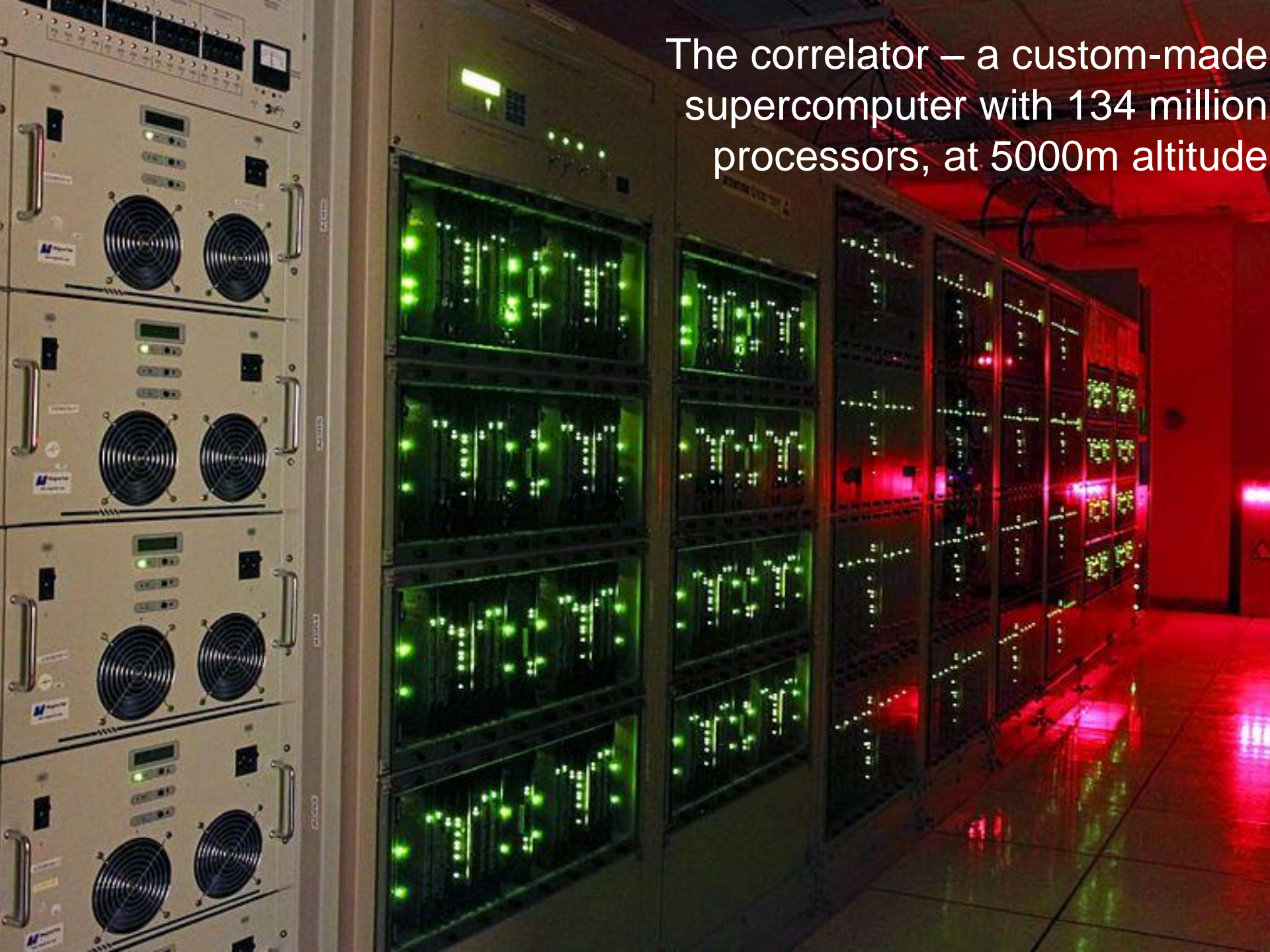








The correlator – a custom-made supercomputer with 134 million processors, at 5000m altitude



Operations Support Facility (OSF), 3000m 30 km from 5000m site



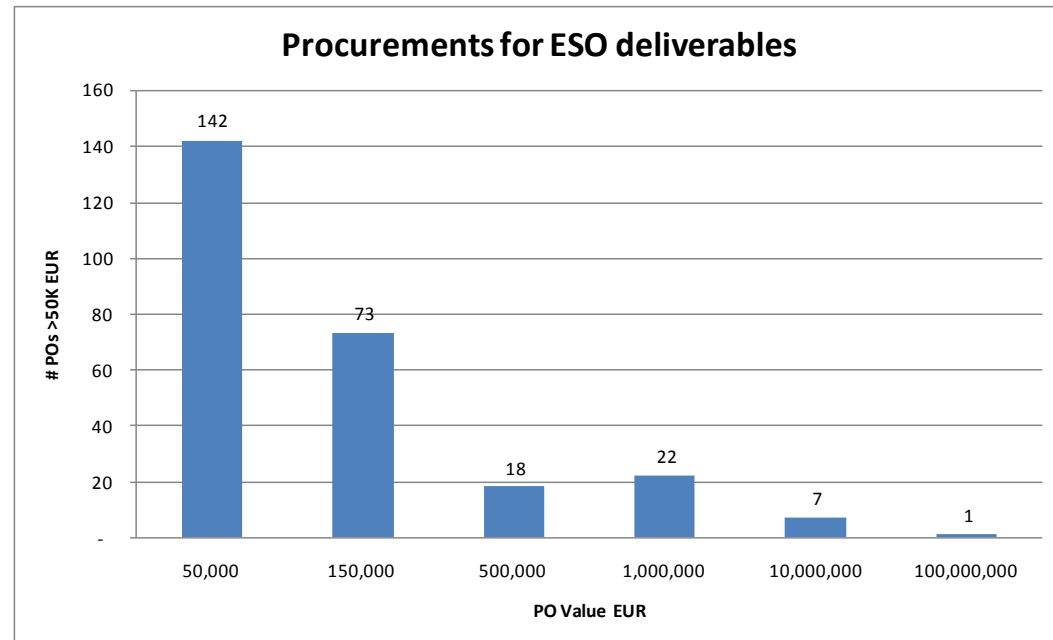
Main ALMA Deliverables

IPT / Subproject	Europe	North America	East Asia
Site Development	ALMA Road to AOS OSF Technical Facilities OSF Residencia Santiago Central Office ALMA Power Supply 192 Antenna Foundations	Roads at AOS AOS Technical Facilities	Financial Contribution to Costs
Antennas	25 Antennas (12m) Two Antenna Transporters	25 Antennas (12m)	4 Antennas (12m) 12 Antennas (7m)
Front End	Band 7 (70) Band 9 (70) Cryostats (70) Water Vapour Radiom. (53) Calibration System (70) 26 Integrated Receivers	Band 3 Band 6 Monitor and Control 26 Integrated Receivers	Band 4 Band 8 Band 10 Integrated Receivers
Back End	Photomixers (hundreds) Digitizers Digitizer Clocks Multiplexers	Optical Transmitters Local Oscillators Digital Formatters Digital De-Formatters	
Correlator	Tunable Filter Boards	Correlator for 64 Ant	Correlator for 16 Ant
Computing	Software	Software	Software

Some major challenges

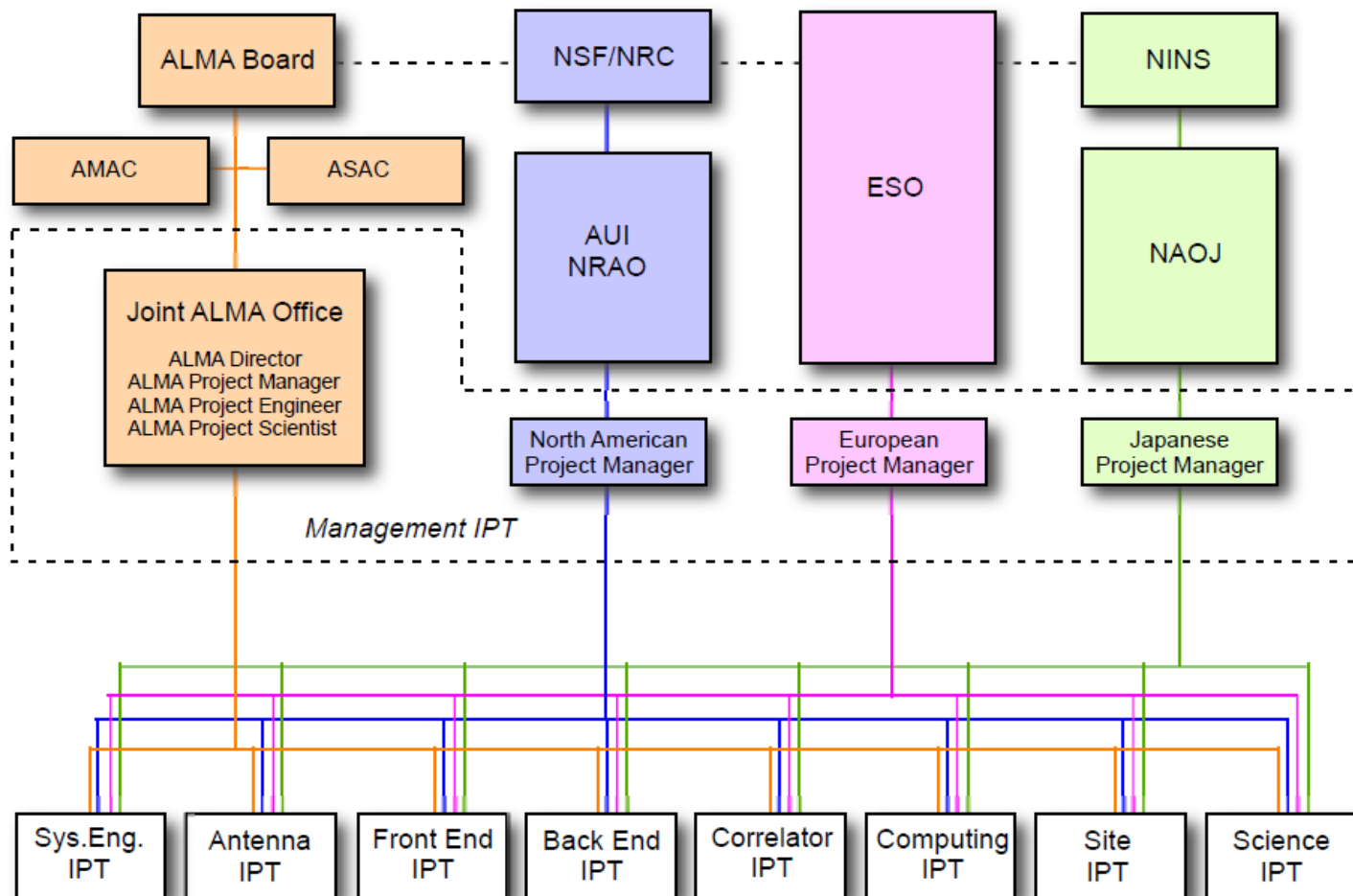
- New technology in several areas
 - e.g. Extensive use of CFRP in antennas
- Demanding antenna & receiver specs
- Transition from single units to “series production”
 - E.g. hundreds of receiver cartridges, 70 front ends, ...
- Most things are custom made items
 - e.g. antennas, receivers, correlator, transporter, ...
- World-wide distribution of design and fabrication
- Complex high-tech system in a remote site
- High and dry desert observatory site (with rain...)
- Three world regions joining their efforts

- ESO deliverables represent ~3500 fte-yr of effort
 - At European institutes and industry, ~45 fte at ESO
 - Probably similar efforts at ALMA partners
- The ALMA scheduling team tracked ~7200 critical deliverables for the three Executives
- ESO contracts:
 - > 100 M€: 1
 - > 10 M€: 7
 - > 1 M€: 22
 - > 500 k€: 18
 - > 150 k€: 73
 - > 50 k€: 142



ALMA Management Structure (during construction)

- The three Executives created the JAO (Joint ALMA Observatory)
- Technical work was done in IPTs (Integrated Product Teams)



ALMA Organization

- ESO, AUI/NRAO, and NAOJ (the 3 “Executives”) agreed to jointly build and operate ALMA
 - Governed by bi- and tri-lateral agreements
 - *Joint ALMA Observatory (JAO)* created in Chile
- The ALMA Board has overall responsibility
- The ALMA Board and JAO are not legal entities
 - Only the three Executives can enter into contracts, employ staff, carry liability etc.
- Technical work was mostly carried out in IPTs
 - IPT = Integrated Product Team

Governance issues

- Each Executive uses its established business and administrative procedures
- Complex relationship between JAO and executives
 - JAO is to provide central leadership while all deliveries came from (“independent”) executives
 - At times unclear who is in charge
 - Executives are at the same time “parents & butler”
 - Mutual “service” attitude required
- Multiple loyalties required

Financial control

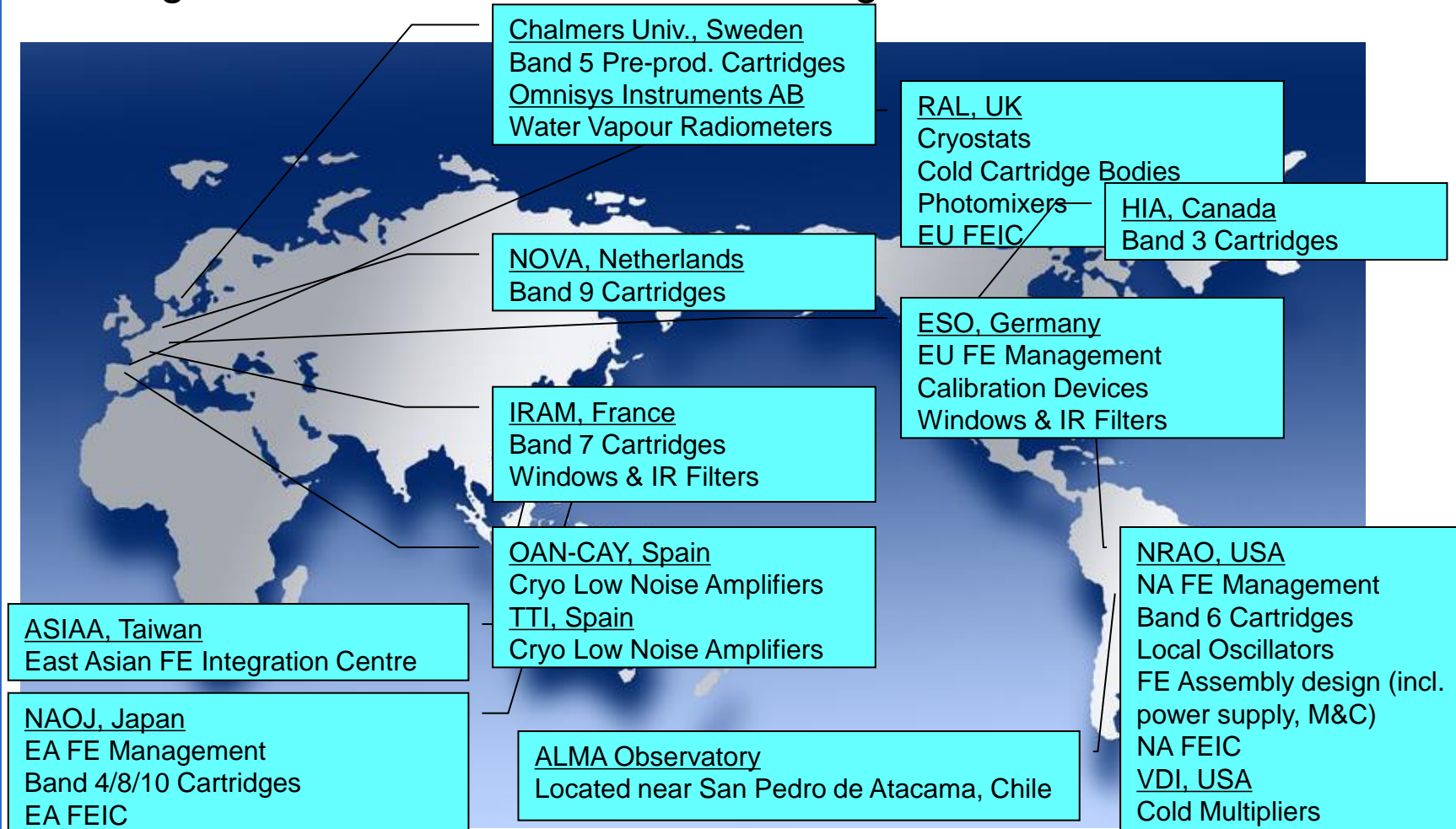
- Each Executive manages its own budget
 - Under their own rules, processes, approvals, etc.
- JAO operates under “shared cost”
 - JAO managed budgets held by executives
 - Annual cost reconciliation between Europe and North America, with East Asia contributing 25%
 - JAO managed budgets have a risk of “broken accountability”
- Defined values mostly ok, with exceptions
 - Values of “High-tech” deliverables was basically ok
 - Values of “low-tech” deliverables (infrastructure) underestimated

Successes

- First collaboration of this kind actually built ALMA
 - Within budget which was set in 2006 (despite significant cost increases in some areas)
 - Meeting demanding design specifications
- “Series” manufacture of state-of-the-art technology without loss of performance
 - Built up three *Front End Integration Centers* (UK, USA, Taiwan)
- Early Science started already in 2011
 - Stunning science results
- Strong desire and motivation on all sides helped overcoming difficulties

Front Ends

- Components produced worldwide, >7000 deliverables
- Integrated into Front Ends in three Integration Centres



Organizational challenge

■ Organizational

- The three Executives are well established organizations in their respective region
- With their own culture, boundary conditions, funding streams, procurement processes, administrative processes, financial year, etc.

■ Different ways and mentalities

- Shows e.g. in expectations, decision processes, formal vs. non-formal, communication habits, ...
- Mutual respect, continuous communication and clear agreements are key ingredients



