

**Atacama  
Large  
Millimeter  
Array**

# The ALMA Project

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# ALMA Phase 1

- Project definition, preliminary design and development conducted under MoUs
  - North America (1998-2001)
  - Europe (1999-2002)
- Each partner has contracted for development of a prototype 12-meter antenna

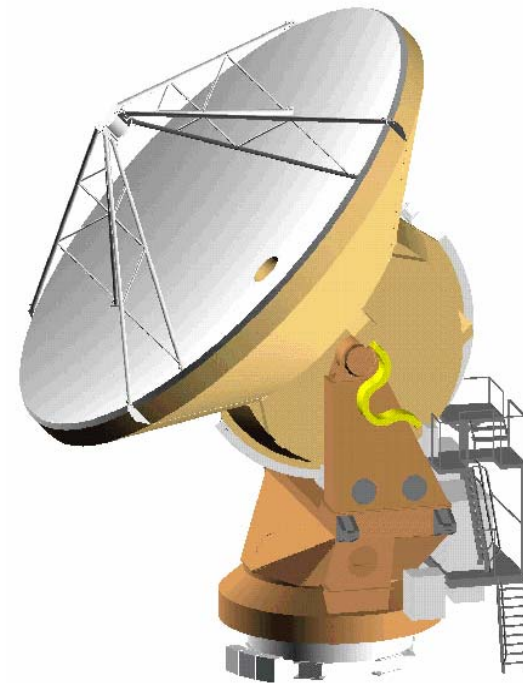


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# Prototype Antennas



VertexRSI



Alcatel/EIE



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# ALMA Phase 2

- Detailed design, construction and operation under an international Agreement
- Bilateral Phase 2 started in 2002
  - US Phase 2 funding approved in Nov 2001
  - ESO Phase 2 funding approved in Jul 2002
  - ESO-Spain Agreement signed in Jan 2003
  - ESO-NSF Bilateral Agreement signed in Feb 2003
- Construction is scheduled to be completed by end of 2011



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## ALMA Phase 2

- Each partner appoints an Executive to carry out the tasks required to construct ALMA
  - European Southern Observatory (ESO) for Europe
  - National Radio Astronomy Observatory/ Associated Universities Inc. (NRAO/AUI) for North America



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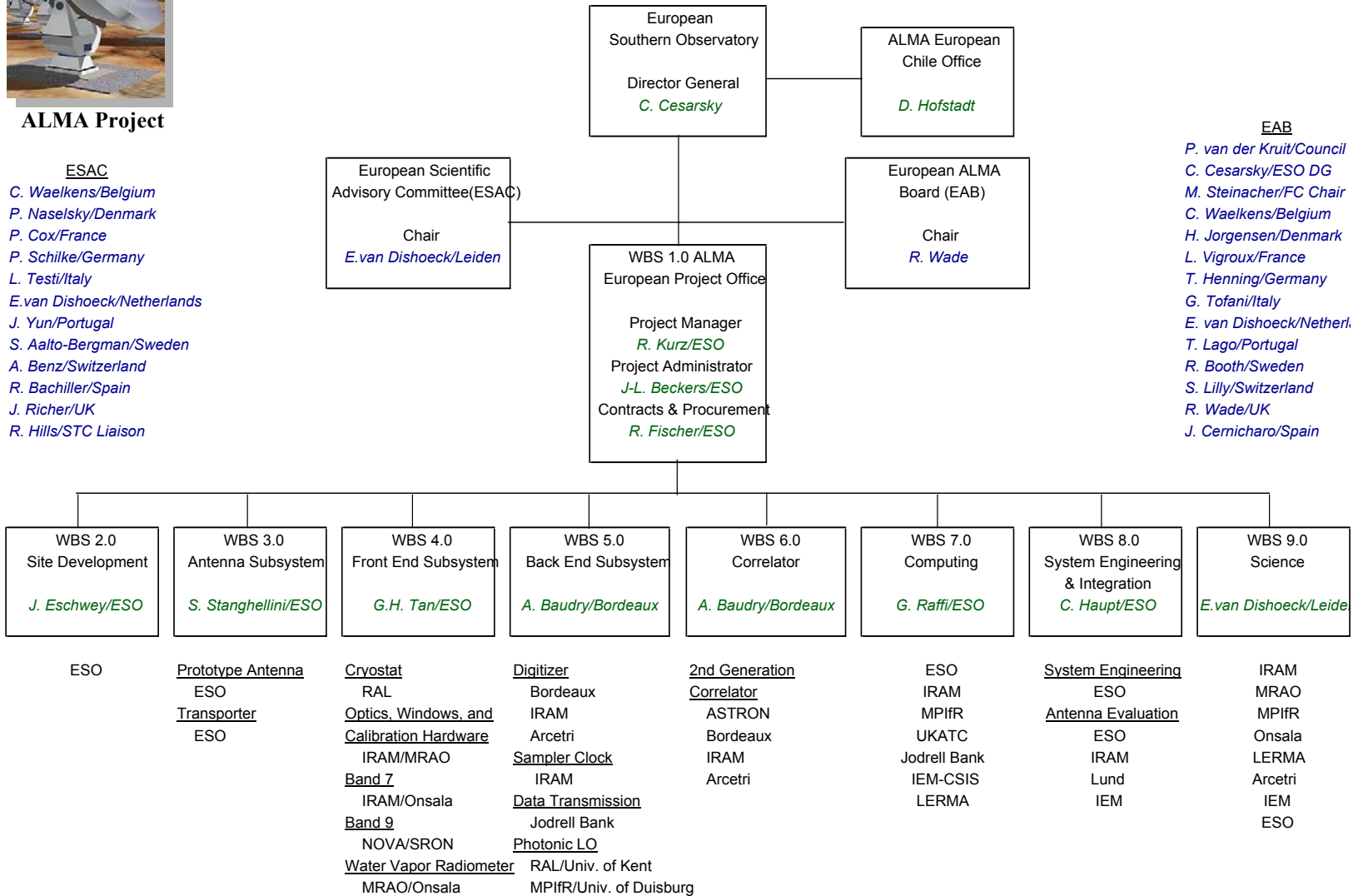
# Level - 1 ALMA Milestones

- **Q4 2002** **Start prototype antenna evaluation at ATF (done, Q1 2003)**
- **Q4 2003** **Begin civil works in Chile**
- **Q1 2005** **Central back end system ready to install at array site**
- **Q2 2005** **Initial phase of civil works in Chile complete**
- **Q2 2005** **First antenna-based back end system ready for installation**
- **Q4 2005** **First production antenna available at OSF**
- **Q4 2005** **First front end system available at OSF**
- **Q3 2007** **Start initial science operations**
- **Q4 2011** **Construction complete**
- **Q1 2012** **Start full operations**



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# ALMA European Organization





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# Distribution of ALMA Phase 2 Responsibilities

- Work Breakdown Structure defines all tasks
- Estimated cost, including a contingency based on risk, and schedule agreed for all tasks
- Distribution of task responsibilities negotiated that balances cost, risk, and interests of the partners



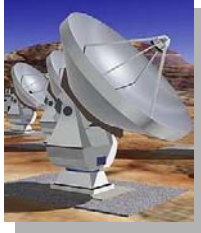


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# Work Breakdown Structure

- Management and Administration
- *Site Development*
- *Antenna*
- *Front-end Electronics*
- *Back-end Electronics*
- *Correlator*
- *Computing & Software*
- System Engineering & Integration
- Science

*Italics indicate areas in which ALMA expects to contract with industry*



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# ALMA Contracting

- ALMA contracts will be awarded and administered by the responsible Executive (ESO or NRAO)
- The ALMA Agreement states:
  - The Executives shall, to the maximum extent practicable, make awards on the basis of competitive international tender in a manner which shall enable competitive bidding by companies within the respective partner's countries on terms which are not selectively to the disadvantage of the companies of any of those countries.



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# ALMA Contracting

- Development activities will continue through 2002 and 2003
  - Most development work done by “academic” institutions with limited opportunities for industrial participation
- Series production contracts
  - Tendering in the 2004 timeframe
  - Deliveries spread from 2005 through 2011



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# Negotiations with Chile

- Top – Level Requirements:
- permissions for AUI and ESO to build/operate ALMA;
- long-term (50-year) access to the ALMA site;
- sale of land to ESO and AUI for an operations base at 2800m elevation – the Operations Support Facility;
- an approved Environmental Impact Statement.



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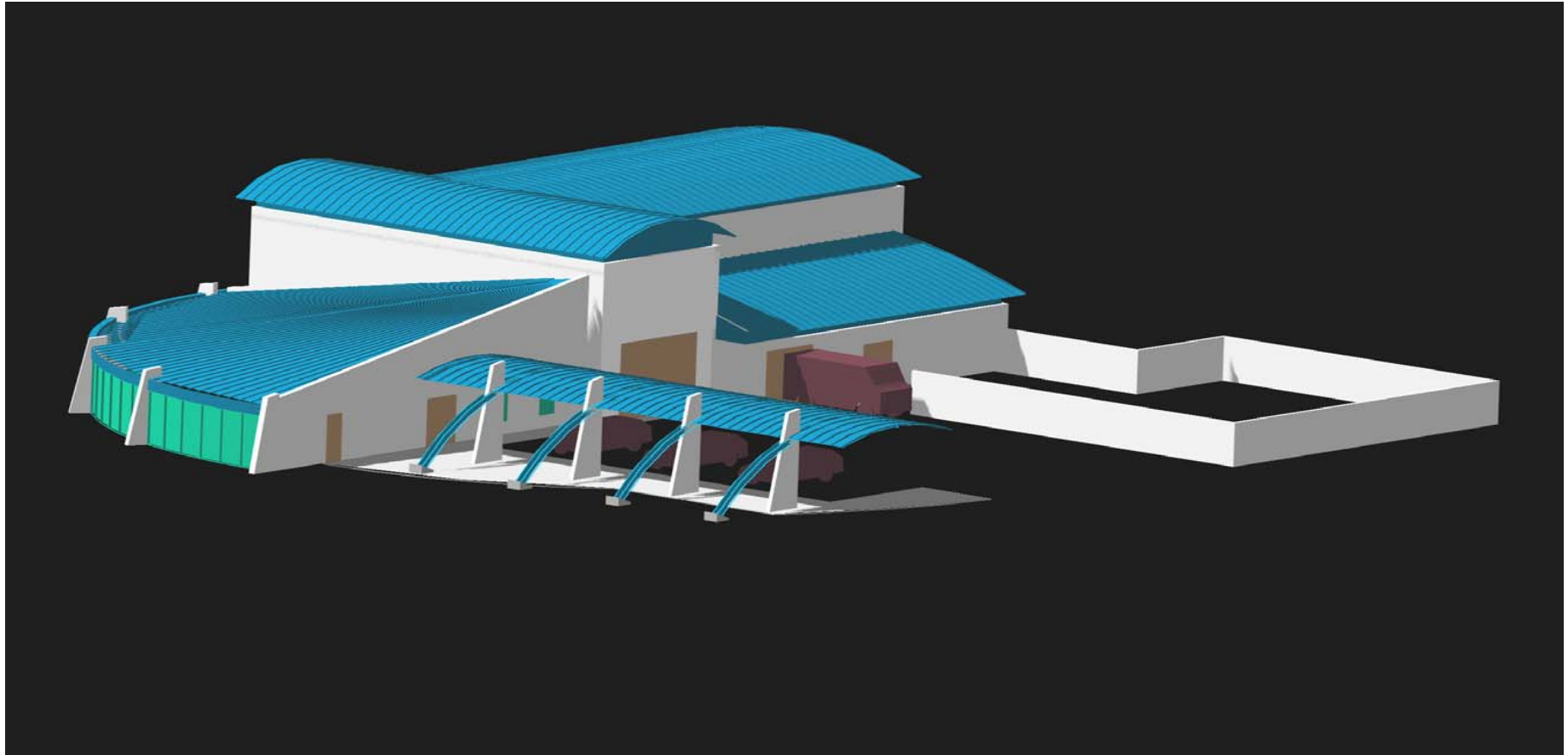
# Site Development

- Construction of facilities in Chile
  - Open to international competition - expect strong participation by Chilean industry
- Infrastructure
  - Electrical power generation and distribution
  - High data rate ( $>10$  Gbps) communications links within and between ALMA sites in Chile



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## Antenna Operation Site Technical Building Concept





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# ALMA Sites in Chile



Antenna Operations Site (AOS)

40 MB/s (peak)

Operation Support Facility (OSF)

6 MB/s (average)

Santiago Central Office (SCO)





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# Antennas

- Series production of 64 12-meter antennas
  - CFRP structures
  - Steel structures
  - Antenna components - bearings, encoders, cable wraps, equipment racks, air conditioning
  - Azimuth and elevation drive systems
  - Antenna control system
- Antenna transporter vehicles





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# Antennas

- Production antenna design will be based on the results of the prototype antenna evaluation
  - Alcatel Space/EIE consortium (Europe)
  - VertexRSI (North America)
- Production antenna Call for Tenders should be released in Oct 2003



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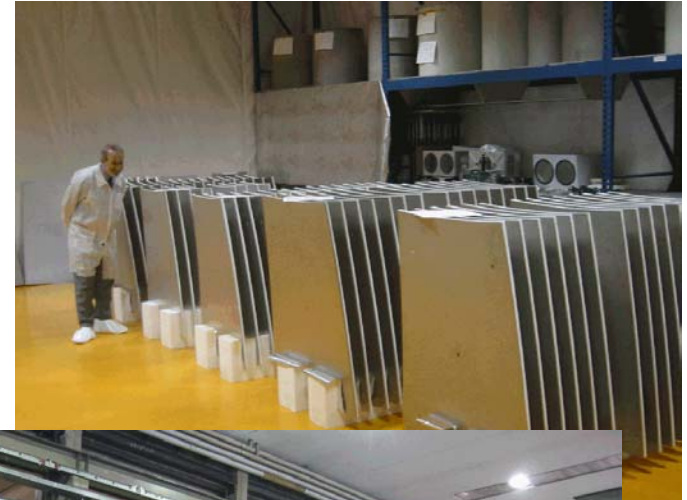


Vertex  
antenna  
at VLA  
site +  
nutator



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# AEC prototype antenna components

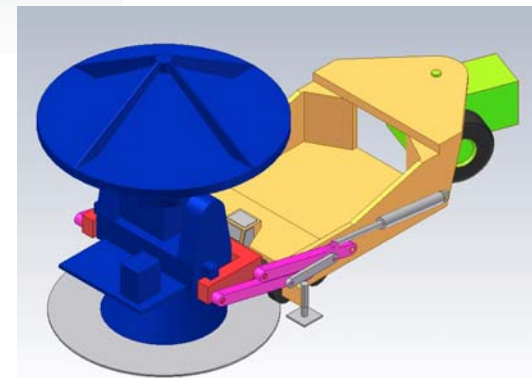
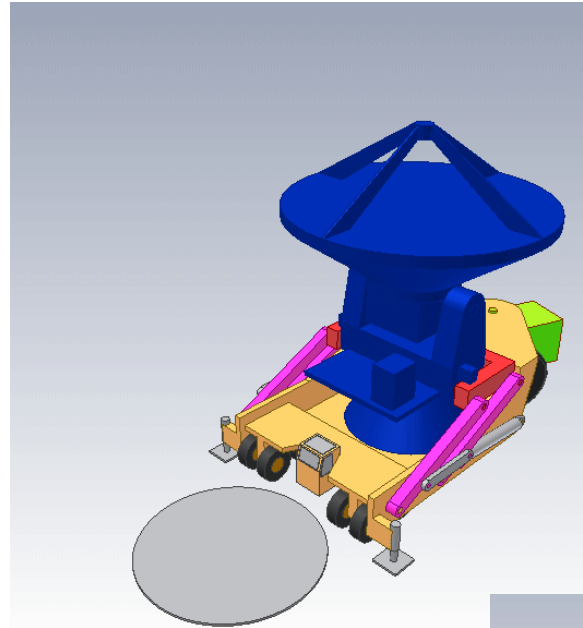




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# ALMA Antenna Transporter

- **Development of concept based on existing industrial vehicle.**
- **Advantages of this concept:**
  - Relatively low mass
  - Modularity based on existing subassemblies (*tractor*)
  - Acceptable road width
  - Not necessary to drive on foundation

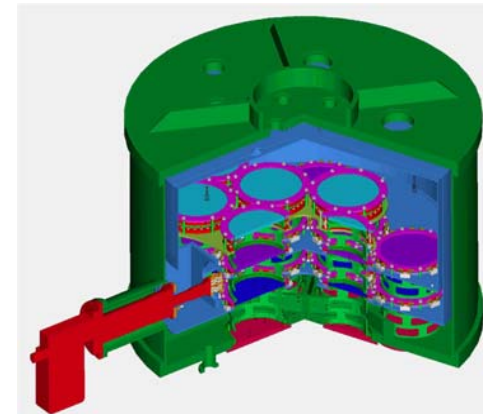
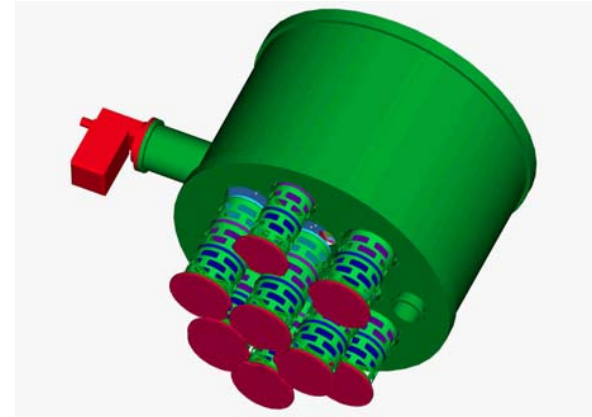




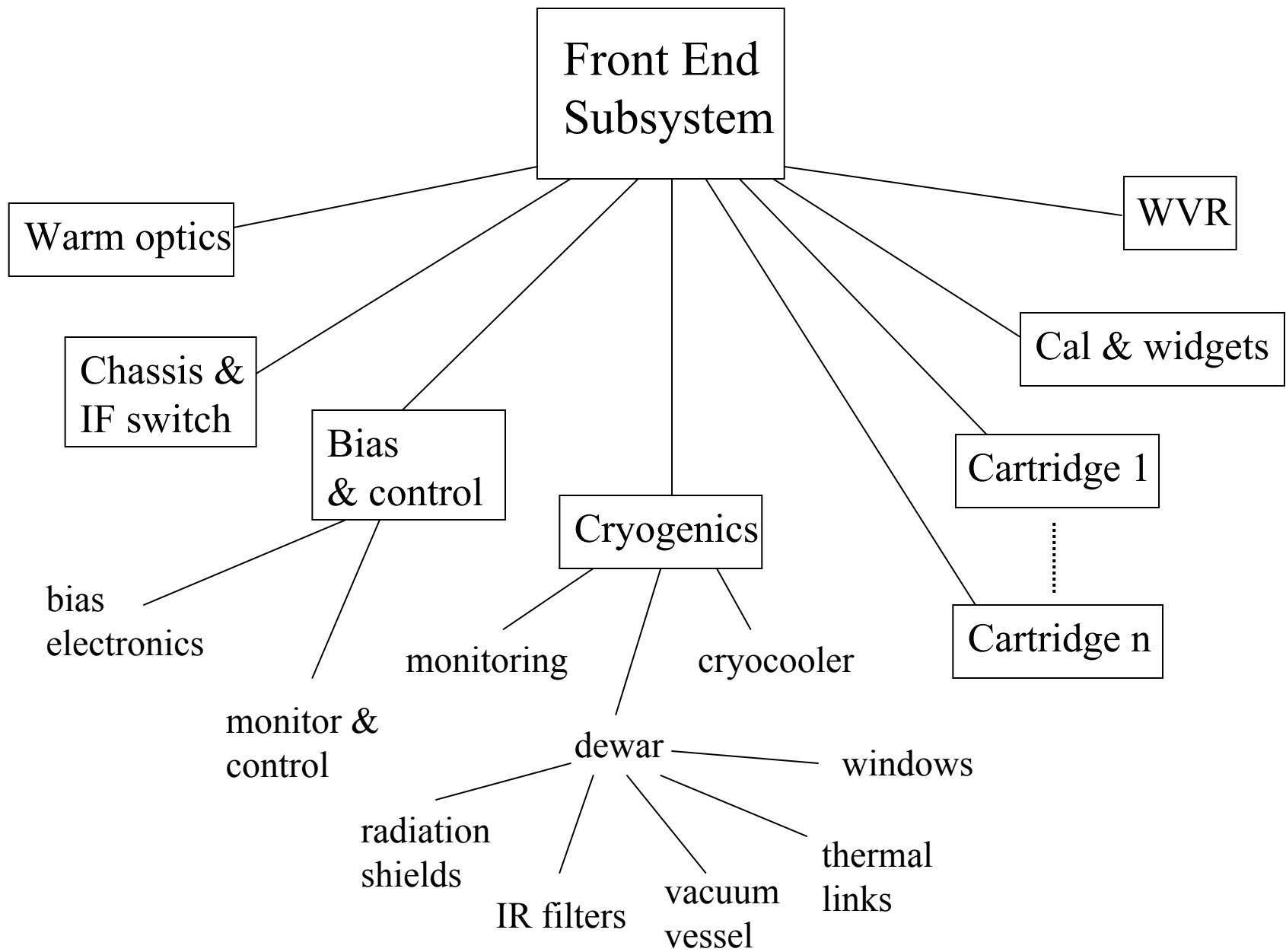


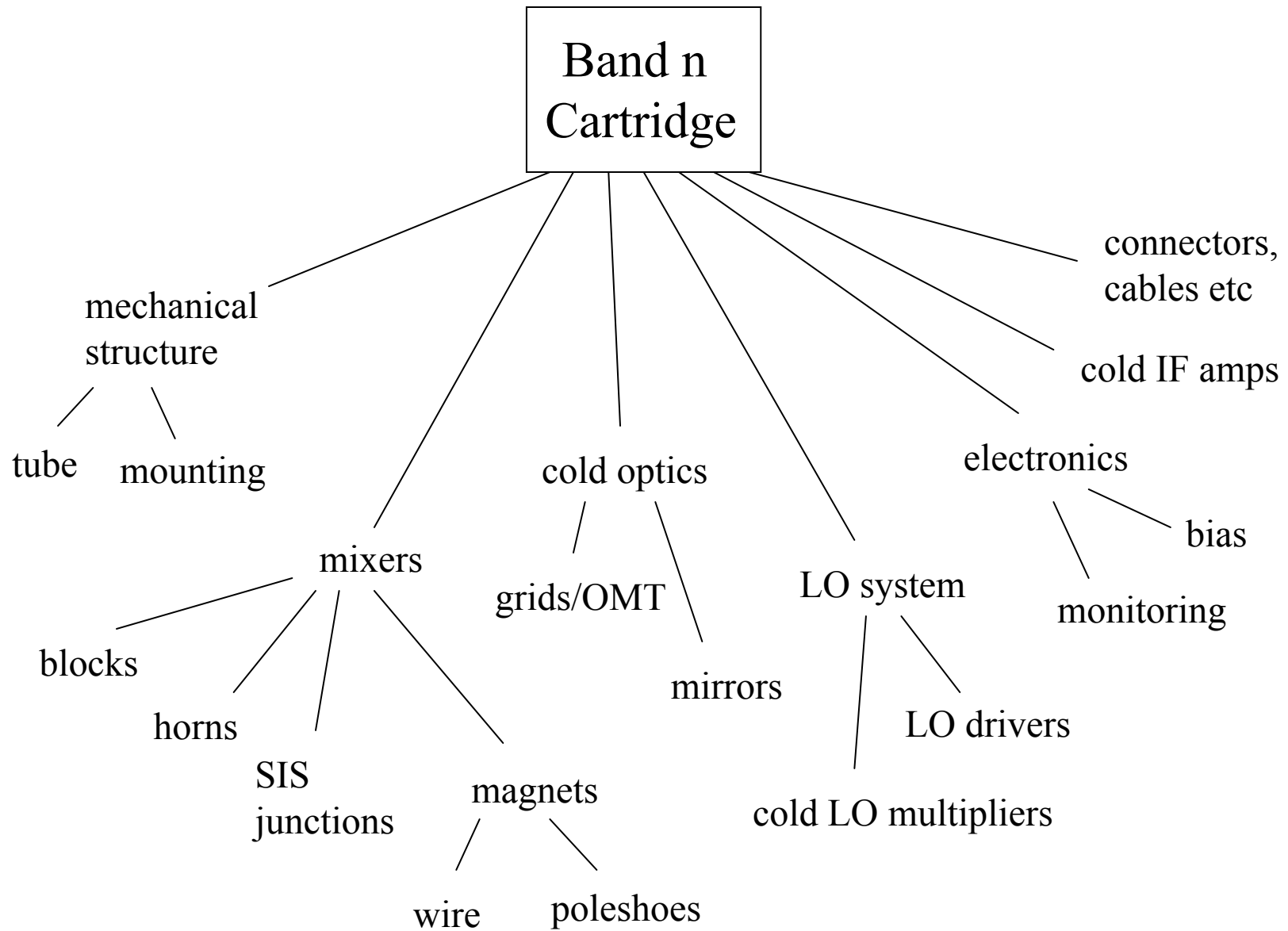
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# Front End Design



- Diameter  $\sim 1$  m
- External optics top of dewar
- 10 Cartridges plugged from bottom
- Each cartridge contains one frequency







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# Back End & Correlator

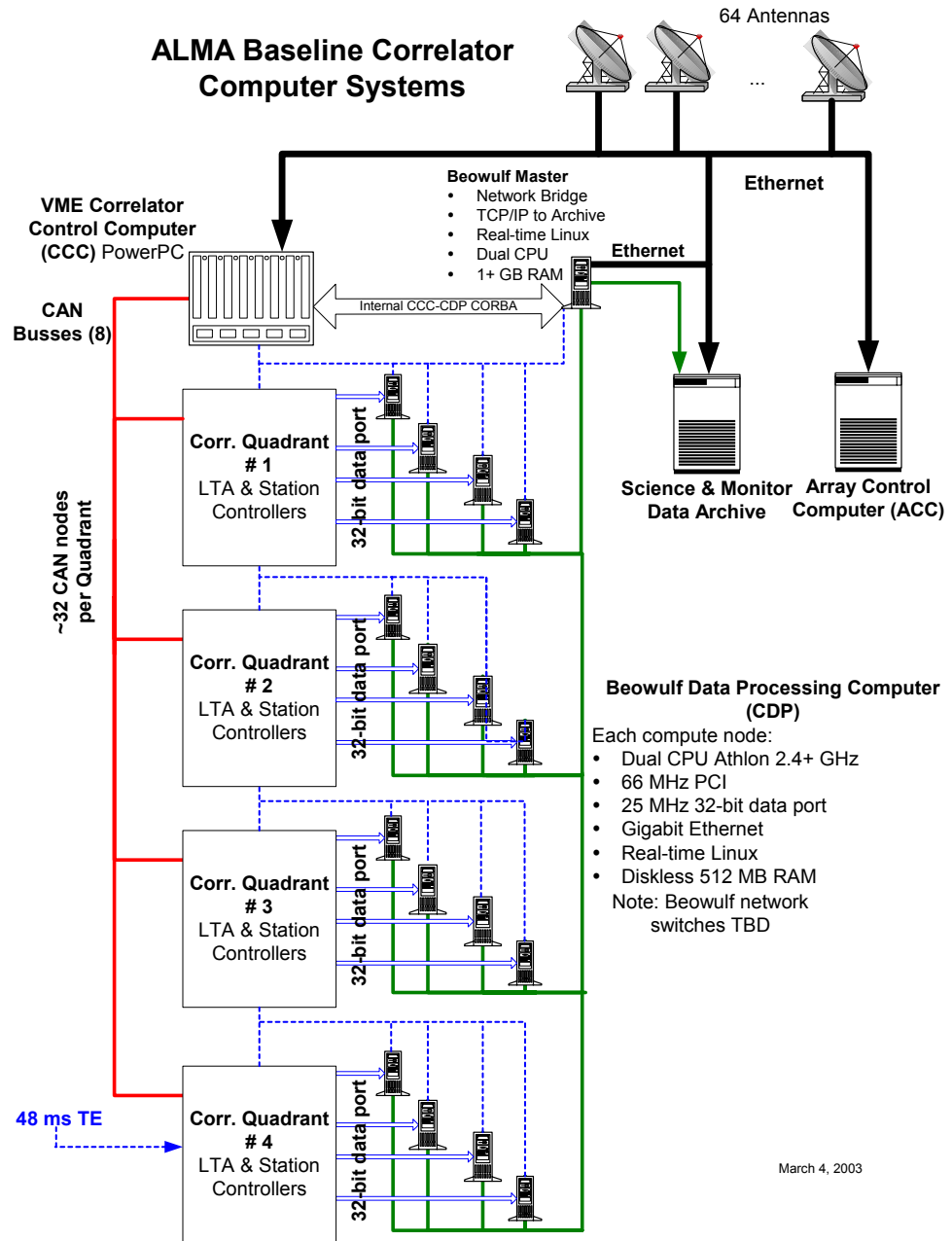
- High speed digitizer
  - 3-bit, 4 Gsamples/s
  - Associated 4 Ghz sampler clock and demultiplexer
- IF digital data transmission system
  - 120 Gbps fiber optic link from each antenna
- 2nd Generation Correlator
  - Design and development of higher efficiency, higher spectral resolution correlator for future implementation





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# Correlator Computer Architecture





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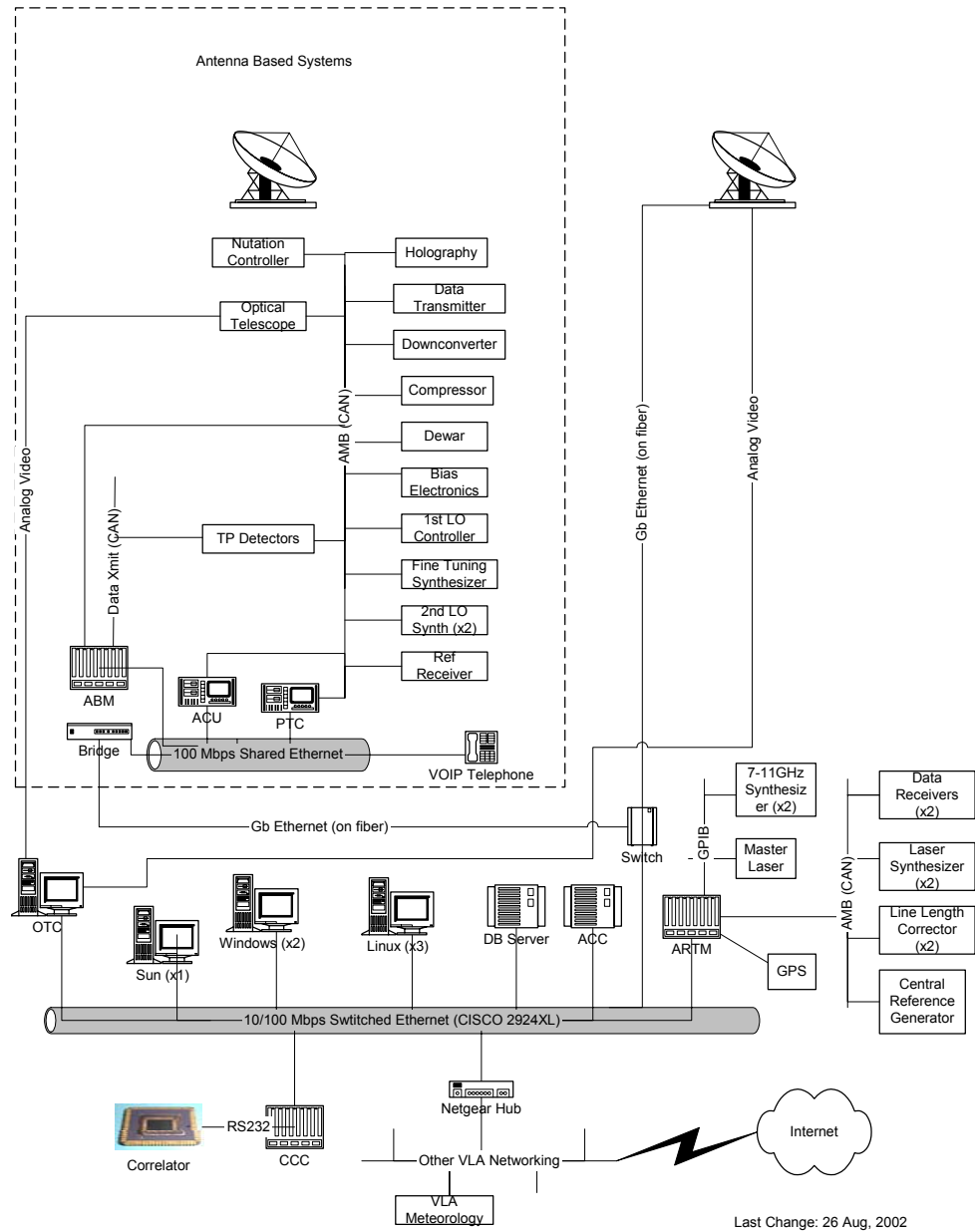
# Computing

- ALMA Computing works as one group across USA and Europe (responsibilities 50/50%)
- Work done in Phase1 includes:
  - Science Software Requirements (SSR)
  - High-Level Analysis and Architecture Design (A&D)
  - Software Engineering Practices (SE)
  - ALMA Common Software (ACS) - Java and CORBA-based framework for all ALMA software



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# ALMA Computers





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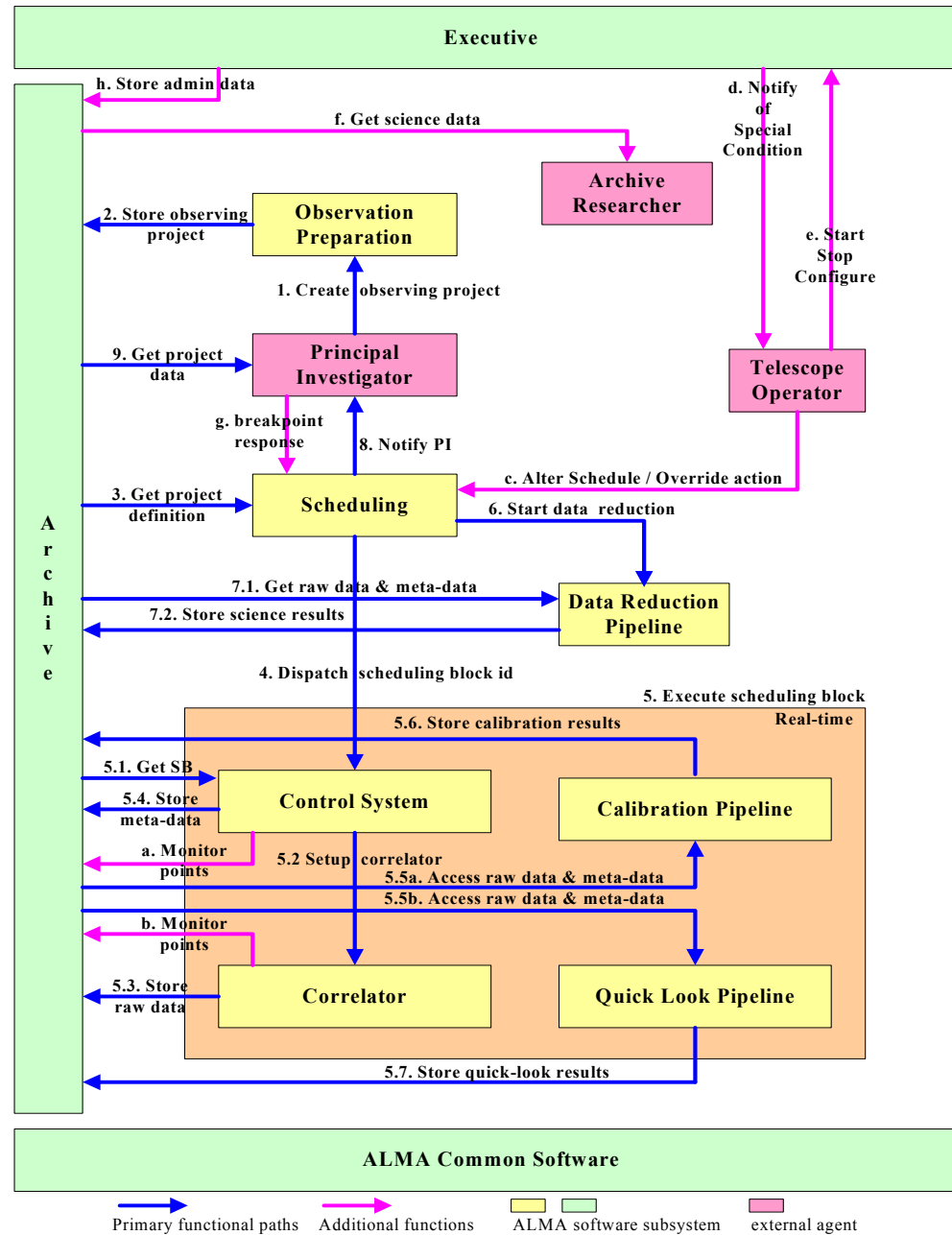
# Computing

- European responsibilities in Construction phase
  - Global activities: SSR, A&D, SE, ACS
  - Subsystems: Archiving, Telescope Calibration, Off-line User Interface, Executive software, Proposal Preparation
- ALMA Institutions involved with Computing in Europe: ESO, IRAM, IEM-CSIC, MPIfR, LERMA, ATC, JBO...
- Industry can play a role in software embedded in other subsystems - antennas, front ends...



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# ALMA Software Architecture





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# Japanese Participation in ALMA

**Japan is likely to join ALMA starting April 1, 2004 (on a < 1/3 basis).**

**Enhancements being discussed:**

- **ALMA Compact Array = (12) 7m + (4) 12m antennas in a closely packed configuration to provide sensitivity to diffuse sources and enhanced submm capability;**
- **Additional receiver bands = Band 4 (125-163 GHz ), Band 8 (385-500 GHz ), and Band 10 (787-950 GHz );**
- **Share of infrastructure.**