SPARK/Ada Software for CubeSats
FOR ULTRA-RELIABLE SOFTWARE

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Why Use Ada?
- If the software fails, we would also lose the satellite cost of $30,000-$50,000 and launch cost of $80,000-$100,000 and several years’ effort
- Ada offers a greatly improved probability of error-free software when compared with C, which is used in most CubeSat projects
- The development and debugging time would be less, which is helpful with our smaller resource base
- Students get learn and use the best software engineering features in Ada in a real-world embedded system

Ada and SPARK
- Allows for a further increase in software reliability
- Allows for various conditions to be checked by static analysis
- Although small by SPARK standards, our Arctic Sea Ice Buoy and CubeSat have only one chance to get the software right
- A rare opportunity for our students to work on a real-world, very high-integrity system using the best tools available
- The elimination of the run-time system for the Arctic Sea Ice Buoy
- High-integrity realtime programming using the RavenSPARK subset of the Ada Ravenscar Tasking Profile for the CubeSat

AdaMagic
- There is no Ada compiler for the Texas Instruments MSP430 series of processors that we are using
- The AdaMagic compiler front end which produces ANSI C as the intermediate language allows us to do the projects in SPARK/Ada
- The C output from AdaMagic is then run through the Rowley Crossworks cross compiler to produce object code for the MSP430
- This same procedure, for a different purpose, was discussed by Praxis at the Ada Europe 2004 conference in “High Integrity Ada in a UML and C World”

Other SPARK/ADA information
- In a 10,000-line program, Tokeneer, written in SPARK/Ada for the National Security Administration, after two years of testing, NSA found only one error
- The complete Tokeneer project can be found at: http://www.adacore.com/home/products/gnatpro/tokeneer
- In a large mixed language avionics project, Ada had 10% of the C error rate, while SPARK/Ada had only 1% of the C error rate

Arctic Sea Ice Buoys
- Buoys will share hardware and software with our CubeSat
- Measures: Wind speed, direction, temperature and GPS position
- Data uploaded to Iridium Satellites, via Short Burst Data Modem Service
- Ultra low power Texas Instrument MSP430 CPU on Lithium thionyl chloride batteries
- Working on the simpler software for the buoys will give us experience before tackling the much more complicated CubeSat software
- Sample SPARK/Ada code from the Sea Ice Buoy:

```
procedure ADC_Read
  (Temperature_Value : out Data_Types.Temperature_Type;
   Wind_Direction_Value : out Data_Types.Wind_Direction_Type)
---# global in out ADC.ADC_Hardware;
---# derives ADC.ADC_Hardware from ADC.ADC_Hardware &
---# Temperature_Value from ADC.ADC_Hardware &
---# Wind_Direction_Value from ADC.ADC_Hardware;
is
  TempVal    : ADCValue;
  WindDirVal : ADCValue;
begin
  ADC.Read(TempVal, WindDirVal);
  Temperature_Value := Data_Types.Temperature_Type(TempVal);
  Wind_Direction_Value :=  Data_Types.Wind_Direction_Type(WindDirVal);
end ADC_Read;
```