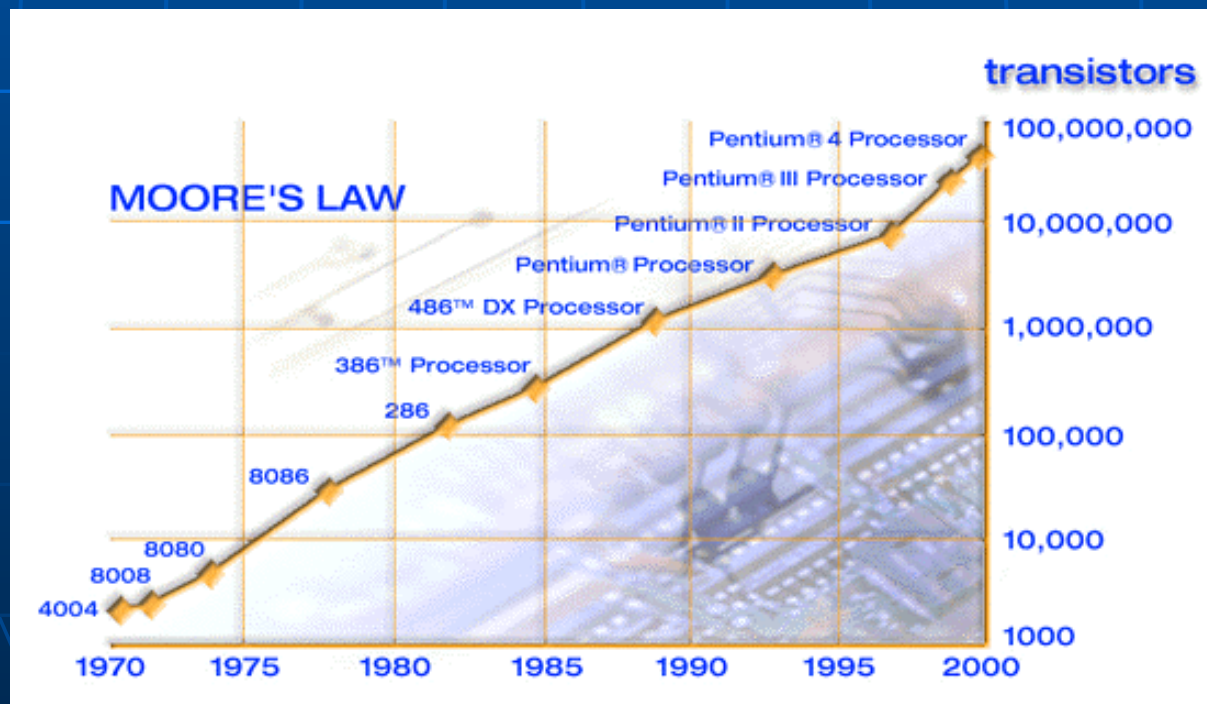


Semiconductor Processing

Brian Sherin

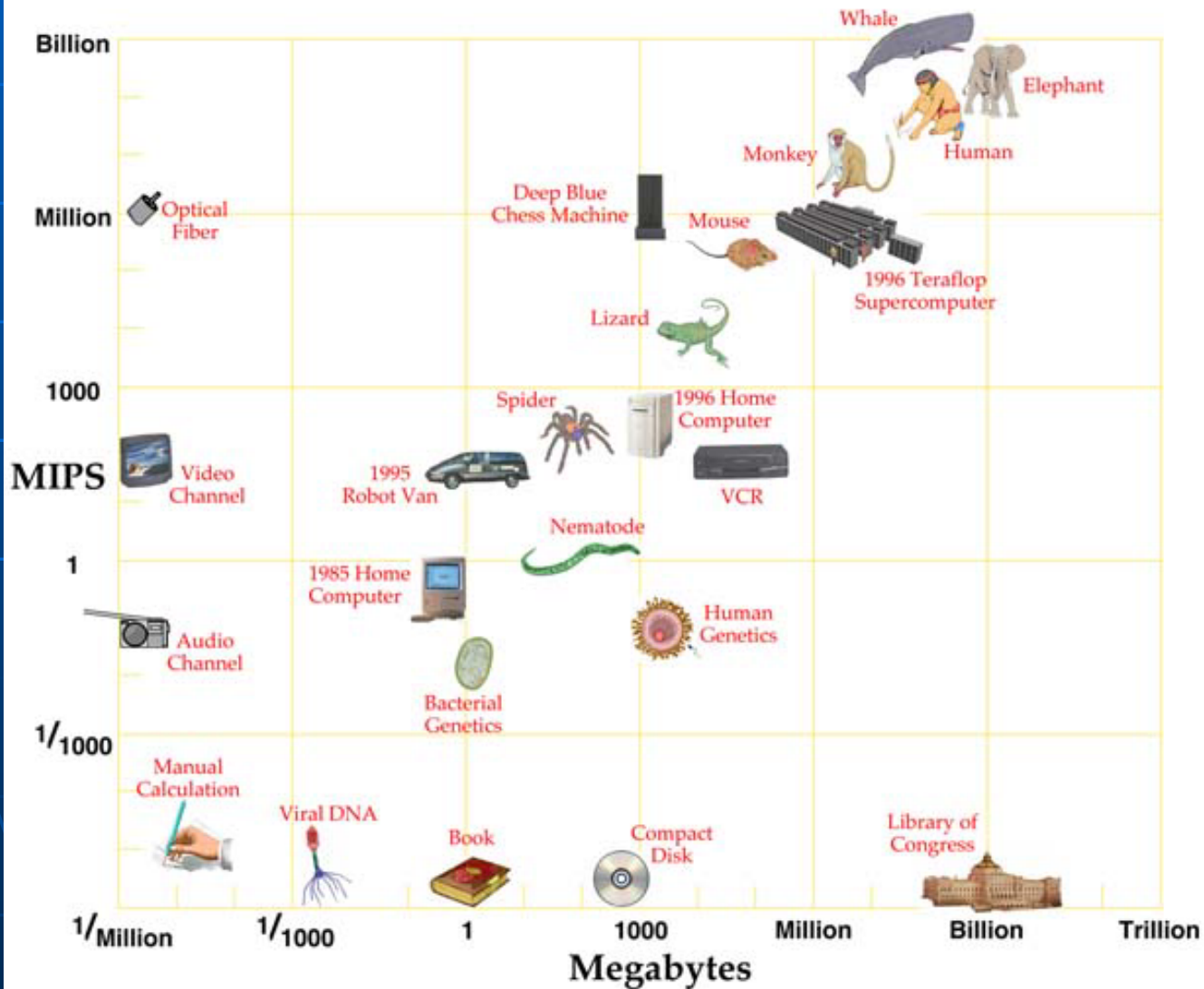
Moore's Law

- Gordon Moore, Intel
 - 1965, 4 yrs after the 1st planar IC was discovered.
 - Predicted that the number of transistors per IC would double every 18 months.
 - Forecast that this trend would continue through 1975.
 - Through technology, Moore's Law has been maintained



Computing Power

All Things, Great and Small

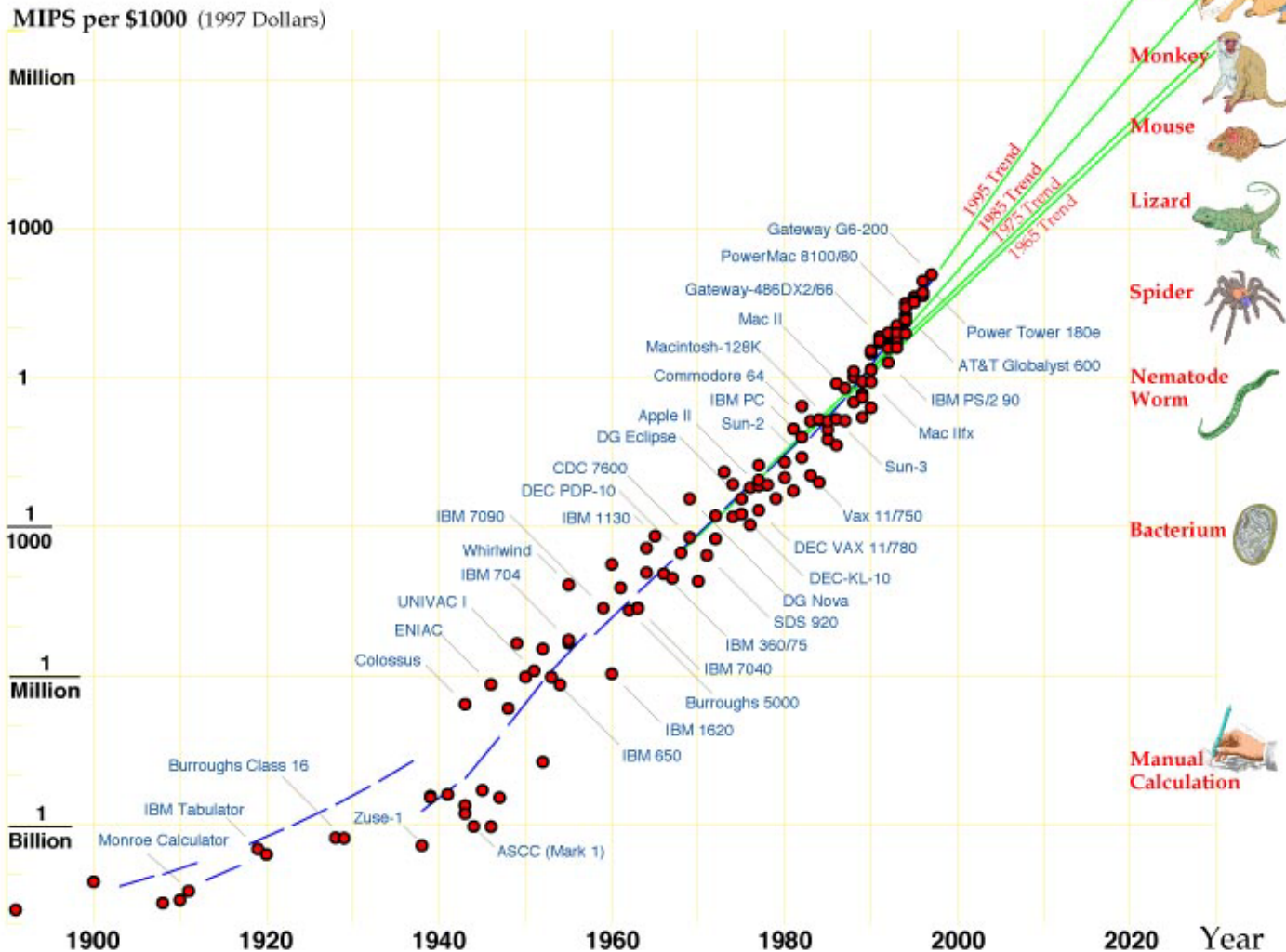


When will computer hardware match the human brain?, Hans Moravec,
<http://www.transhumanist.com/volume1/moravec.htm>

Computing Power / Cost

Evolution of Computer Power/Cost

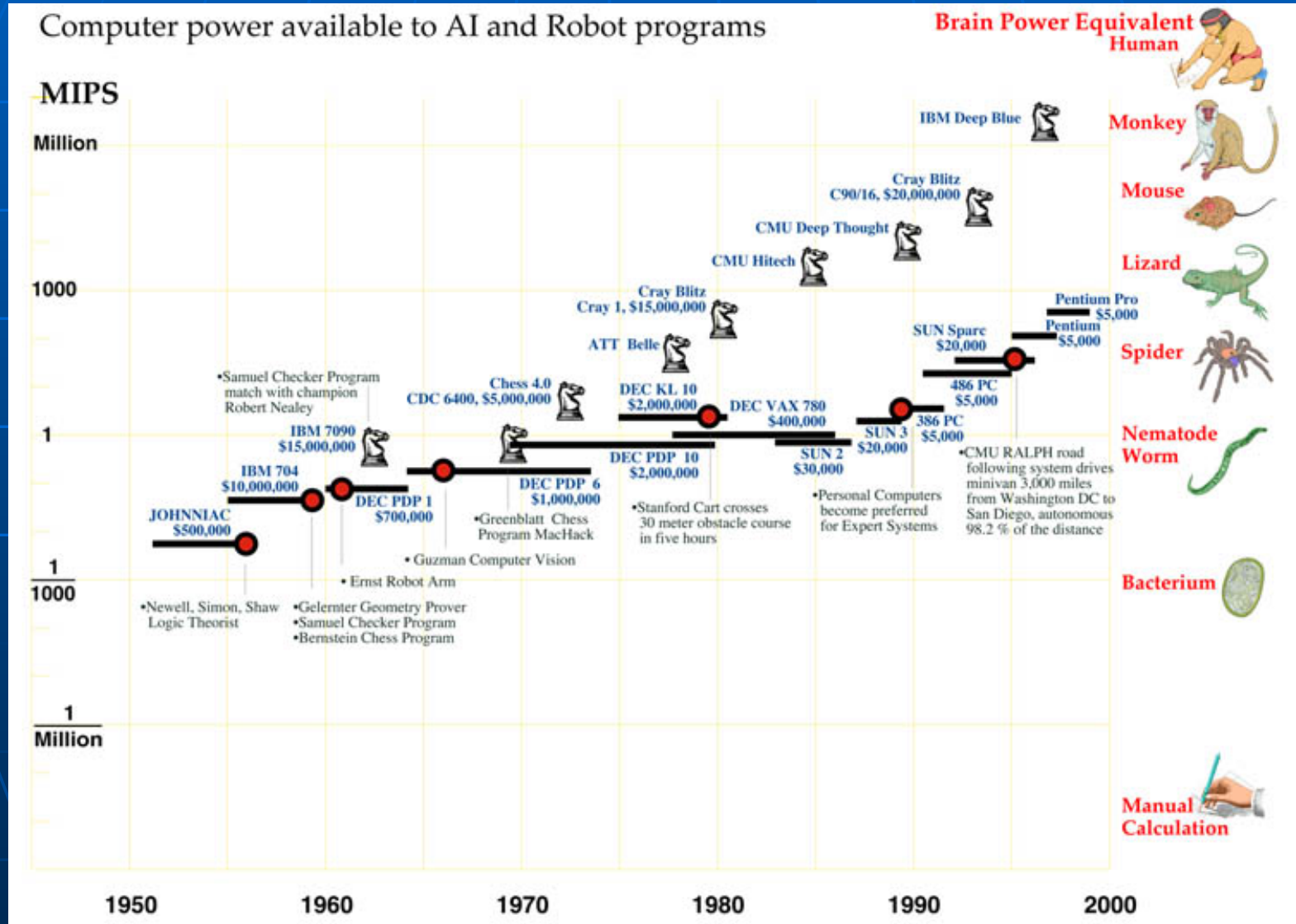
Brain Power Equivalent per \$1000 of Computer



When will computer hardware match the human brain?, Hans Moravec,
<http://www.transhumanist.com/volume1/moravec.htm>

Computer Artificial Intelligence

When will computer hardware match the human brain?, Hans Moravec,
<http://www.transhumanist.com/volume1/moravec.htm>



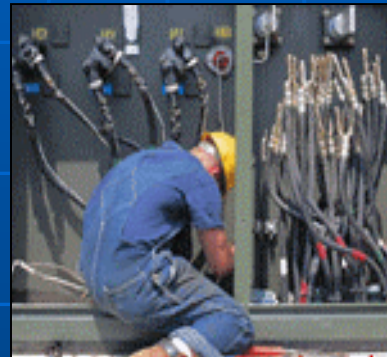
Health & Safety Hazards

Brian Sherin

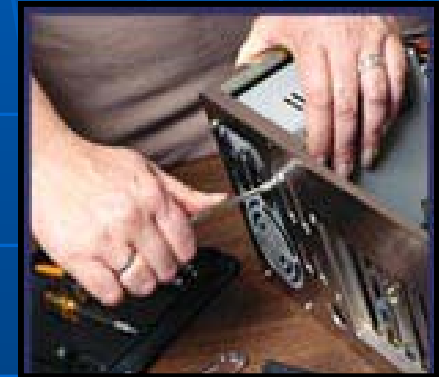
Process & Facility Hazards



**Hazardous
Production
Materials**



Hazardous Energy



Ergonomics



**Man-made &
Natural
Emergencies**



Fire & Smoke

Hazardous Energies

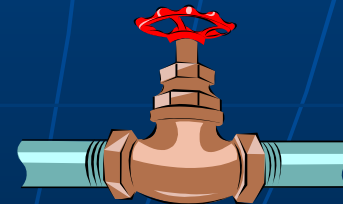
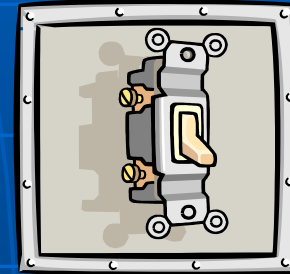
- Mechanical
 - Robotics
- Electrical
 - High & Low Voltage
- Chemical
 - Reactive materials
- Radiation
 - Non-ionizing radiation
- Thermal
 - Cryogenics & heat sources
- Pressure
 - Pneumatic
 - Hydraulic
 - Vacuum

Hazardous Energy: Radiation

- Ionizing radiation
 - Ion implantation, scanning electron microscopes
- Non-ionizing radiation
 - Static magnetic fields (0 Hz)
 - Sub radio-frequency fields (1 Hz - 3 kHz)
 - Power frequency fields (50 or 60 Hz)
 - Radio-frequency fields (3 kHz - 300 GHz)
 - Infrared energy (700 nm - 1 mm)
 - Visible light (400 - 700 nm)
 - Ultraviolet energy (180 - 400 nm)
 - Lasers
 - Noise (CE-MD: > 75dBA)

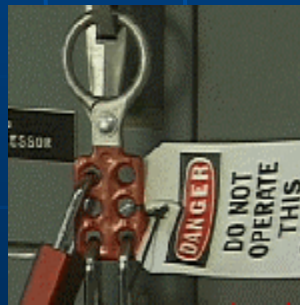
Controls

- Lockout / Tag-out Programs
- Isolation devices
- Interlocks
 - Hardware, software, firmware
- Emergency Shutdown
 - Emergency Machine Off (EMO)
- Operator Notification
 - Audio-visual



Controls

- Administrative controls
 - Type 1 (de-energized) through type 4 ($> 30 V_{\text{rms}}$, $42.4 V_{\text{peak}}$, 60 VDC, 240 VA)
- Certified critical components
- Guards & Enclosures
- Labeling



Hazardous Production Materials (HPM)

■ Physical Hazard

- Explosives
- Compressed Gases
- Flammable & Combustible Liquids
 - Class I-A, I-B, I-C, II, III-A, and III-B
- Flammable solids
- Organic peroxides
 - Class I through V
- Oxidizers
 - Class 1 through 4
- Pyrophorics
- Unstable Reactives
 - Class 1 through 4
- Water Reactives
 - Class 1, 2, 3
- Cryogenic
 - flammable or oxidizing

■ Health Hazard

- Highly toxic or toxic materials
- Radioactive materials
- Corrosives
- Carcinogens, irritants, sensitizers, and other health hazards



HPM Controls

- Building design (H-Occupancy)
 - Quantity dependent
 - Control areas (“fire barrier”)
 - Storage & Dispensing rooms
 - Separation of incompatibles
 - Exit & Service corridors
 - Ventilation / Exhaust systems
 - Clean-room recirculation
 - Sprinkler system design
 - Emergency Power

HPM Controls

- Use & Handling
 - Chemical containment
 - Storage
 - Delivery
 - Materials of construction
 - Workstation ventilation
 - Sub-atmospheric delivery systems
 - Monitoring & Alarms
 - Gas
 - Liquid
 - Point of use treatment systems
 - Automatic and manual shutdowns
 - Process liquid heating systems
 - Excess flow control / restrictive flow orifices
 - Emergency Plans and Teams

Fire Prevention

- Risk assessment must be performed
 - Evaluate materials of construction, regardless of quantity or application
 - Knobs, buttons, contactors, circuit boards, etc.
- Assess
 - size of each component,
 - total quantity and distribution of components
 - inherent properties of the materials
 - Exposure to oxidizers and ignition sources

Fire Prevention

- Risk Assessment: Process Chemicals
 - Evaluate type, concentration, state, temperature and pressure
 - Evaluate available flow, pressure and quantity of chemicals fed from facility
 - Inherent properties of chemicals (i.e., flammability)
 - Exposure to oxidizers and ignition sources

Fire Prevention

- Risk Assessment: Sources of Ignition
 - Internal sources
 - Electrical
 - Chemical (exothermic reactions)
 - Sudden changes in process conditions
 - Mechanical friction
 - External sources
- Risk Assessment: Oxidizers
 - Assume oxygen is available in infinite supply to support combustion
 - Determine if materials of construction may act as oxidizers under normal conditions or when exposed to heat

Fire Prevention

- Reduction of risk
 - Elimination of contributing factor(s)
 - Engineering control
 - Administrative control
- Detection
- Suppression
 - Approved for application



Ergonomics / Human Factors

- Eliminate or minimize ergonomic and human factors related hazards during installation, operation, and maintenance
 - Awkward postures
 - Repetitive motions
 - Access space, clearances, and reaches
 - Lifting of heavy or bulky objects
 - Difficult displays and hand controls
- Situations:
 - Manual handling
 - Wafer and cassette handling
 - Workstation design
 - Display locations



Process Hazard Analysis

- “What If” Analysis
- HazOp Study
- Procedural HazOp Study
- Fault Tree Analysis (FTA)
- Failure Modes, Effects and Criticality Analysis (FMECA)

SEMI S10 Risk Assessment

- SEMI S10-1296 - Safety Guideline for Risk Assessment
- Provides a consistent method for assessing risk associated with any hazard
- Uses severity and likelihood
- Divides risk level into five categories
 - Critical, High, Medium, Low, Slight

SEMI S10 Risk Matrix

RISK ASSESSMENT MATRIX		LIKELIHOOD				
		FREQUENT A	LIKELY B	POSSIBLE C	RARELY D	UNLIKELY E
S E V E R I T Y	Catastrophic 1	Orange	Orange	Checkerboard	Diagonal Lines	Dark Dotted
	Severe 2	Orange	Checkerboard	Diagonal Lines	Dark Dotted	Dark Dotted
	Moderate 3	Checkerboard	Diagonal Lines	Dark Dotted	Dark Dotted	Light Blue
	Minor 4	Diagonal Lines	Dark Dotted	Dark Dotted	Light Blue	Light Blue